AF-902/AF-904 Generation II
Audio Frequency Track Circuit System

Field Maintenance Manual

- Description
- Installation and Adjustment
- Maintenance
- Troubleshooting

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Revision History

Rev.	Date	Nature of Revision
1	July 2010	Initial Release
2	May 2011	Note added to Section 1.5.4.2. Note added to Section 2. Removed old Section 2.4 "Train Detection in Double Crossover". Revised Section 6.5.1.1 and Section 6.5.2.1. Added Section 6.7.2. Revised Table 6-4, Table 6-7, Table 6-9, and Table 6-12.

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1. GENERAL INFORMATION

1.1. Safety Summary

Read and thoroughly understand this manual before attempting any of the procedures listed. Pay particular attention to:

CAUTION

and

WARNING

These headings may appear throughout this manual. Caution statements indicate conditions that could cause damage to equipment. Warning statements indicate conditions that could cause physical harm, serious injury, or loss of life. Always observe standard precautions familiar to trained electrical technicians. Always adhere to all safety regulations stipulated by the railroad.

1.2. Introduction

This service manual is for the AF-902 and AF-904 Generation II Digital Frequency Shift Keyed (FSK) Track Circuit Controller Systems. The AF-902 system is a fully redundant track circuit controller with automatic fail-over operation. The AF-904 system is a non-redundant track circuit controller. When describing features common to both systems, the term "AF-902/904" is used.

The AF-902 and AF-904 Generation II Digital Frequency Shift Keyed (FSK) Track Circuit Controller Systems provide a plug-in upgrade to the prior version of the AF-902/904 systems. A new single module called a Track Circuit System (TCS) replaces the CPU and Auxiliary boards. The Generation II system supports all of the previous communications and track signal features and adds several new Ethernet port features:

- Optional singular or redundant Ethernet interface to the MICROLOK® II controller using MICROLOK Peer Protocol. This option also provides 5-bit speed code data in the messages.
- Enhanced user interface using an integral web server. Using Microsoft's Internet Explorer, the user can connect to the AF-902/904's web server to access all of the data and calibration functions previously displayed only on the system's front panel.
- Remote Monitoring via SNMP. Using this network standard remote monitoring protocol, the user can view the status of many of the AF-902/904's key operating parameters. The AF-902/904 system will also issue SNMP trap messages when system errors are detected.

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1.3. System Overview

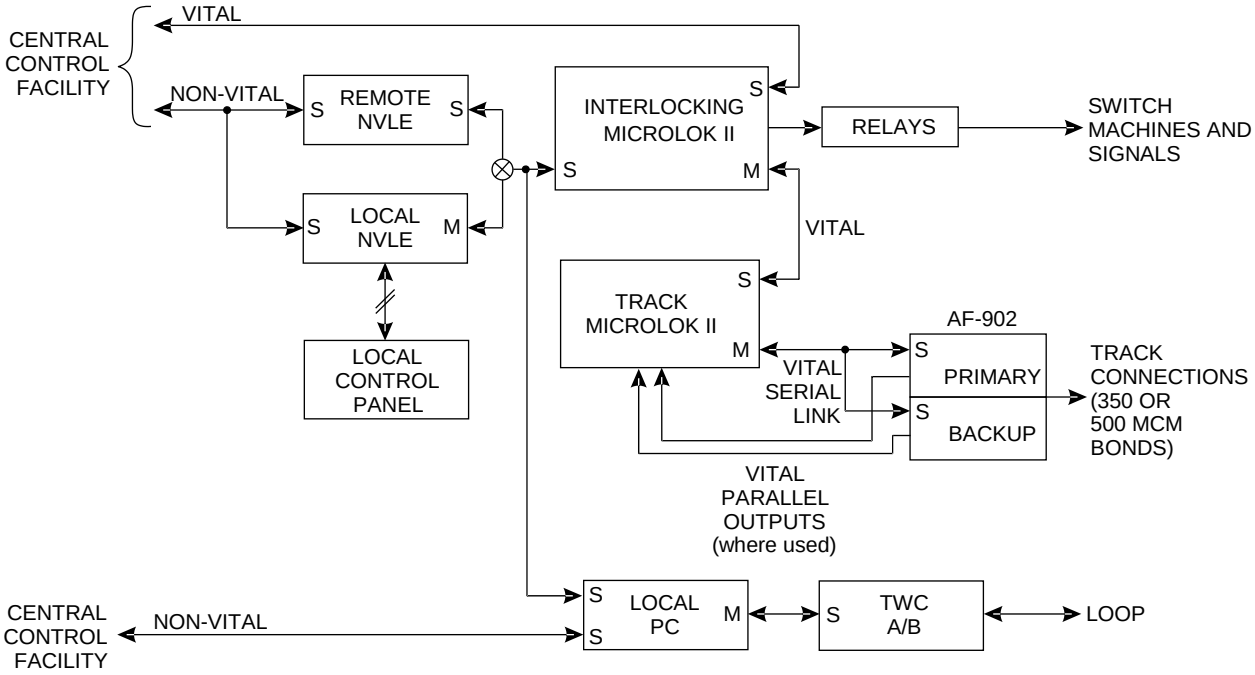
The AF-902/904 system is a wayside component of an Automatic Train Control (ATC) system, providing both train detection and transmission of digital cab signaling data for the Automatic Train Protection (ATP) function. Figure 1-1 shows the AF-902/904 related equipment that is contained in a typical wayside room, using serial communications between the MICROLOK II and AF-902/904 system.

To perform its primary functions of train detection and cab signaling, the AF-902/904 system encodes data from the track logic processor on the wayside and transmits it through the track where the signal is picked up and decoded by the car borne ATP equipment. This data is used for direction, line speed, target speed, track length, next track circuit frequency, berthing, and coupling/uncoupling information.

In Figure 1-1, vital track logic is performed by the Track MICROLOK II system. Interlocking logic and control of switch machines and signals are performed by the Interlocking MICROLOK II. Non-vital logic is performed by Non-Vital Logic Emulator (NVLE) units. Routing is performed automatically by the train ID (through the wayside communications system), from the local control panel, by fleeting, or from central control.

The AF-902/904 system comprises the trackside equipment and processing equipment within the signal equipment room. The trackside equipment consists of track coupling units, wire bonds, and track loops.

As shown in Figure 1-1 the processing equipment for an AF-902 system contains Primary and Backup circuits. The MICROLOK II units and NVLE units may also be duplicated for fail-over conditions.



LEGEND: S = SLAVE
M = MASTER
NVLE = NON-VITAL LOGIC EMULATOR

Figure 1-1. Typical Wayside Room Equipment

1.4. Safety

Read and thoroughly understand this manual before attempting any of the procedures listed. Pay particular attention to:

WARNING

and

CAUTION

statements that appear throughout this manual. Caution statements indicate conditions that could cause damage to equipment. Warning statements indicate conditions that could cause physical harm, serious injury, or loss of life. Always observe standard precautions familiar to trained electrical technicians. Always adhere to all safety regulations stipulated by the railroad.

1.5. Physical Description

This section of the manual provides a brief description of the components of the AF-902 and AF-904 Generation II Digital Frequency Shift Keyed Track Circuit Controller Systems.

CAUTION

This system operates directly from the AC mains. Use caution when working near the backplane or on the power supply, and especially when working on a TCS of Power Supply mounted on an extender board.

1.5.1. Cardfile

The AF-902/904 cardfile chassis is compatible with a standard 19-inch wide rack. All power is supplied to the system circuit boards via the backplane motherboard. The cardfile requires two 115 VAC ± 10% at 50/60 Hz (nominal) power connections. Each line connection feeds power to one half of a power supply which supplies the TCS with the required voltages. Both Primary units in the AF-902 cardfile are powered from the same AC power feed. Both Backup units are powered from the same, second AC feed.

Figure 1-2 shows the layout of a AF-902/904 cardfile. Each cardfile contains six circuit boards, all of which plug into the interconnecting motherboard mounted on the back of the cardfile.

In AF-902 systems, each cardfile contains two redundant track circuits. Each half of the cardfile contains two TCS units and a single Power Supply. The Power Supply board provides two independent supplies, for the Primary and Backup units of one track circuit.

The AF-904 cardfile has the same layout for four independent non-redundant track circuits. The four TCS and two Power Supplies are configured as four separate track circuits.

The AF-902/904 is modular in design, which allows for easy removal and replacement of individual circuit boards. Each TCS in an AF-902/904 system stores its configuration parameters on an EEPROM mounted on the cardfile backplane. Replacement of a TCS may be done with little reconfiguring. A calibration procedure must be performed to verify proper track circuit operation. A full configuration and calibration must be performed whenever a new TCS is used to replace the CPU and Auxiliary boards of an older system.

Connectors for the track circuit connection, serial communications to a MICROLOK II, calibration jumpers, and AC power are on located on the rear of the cardfile.

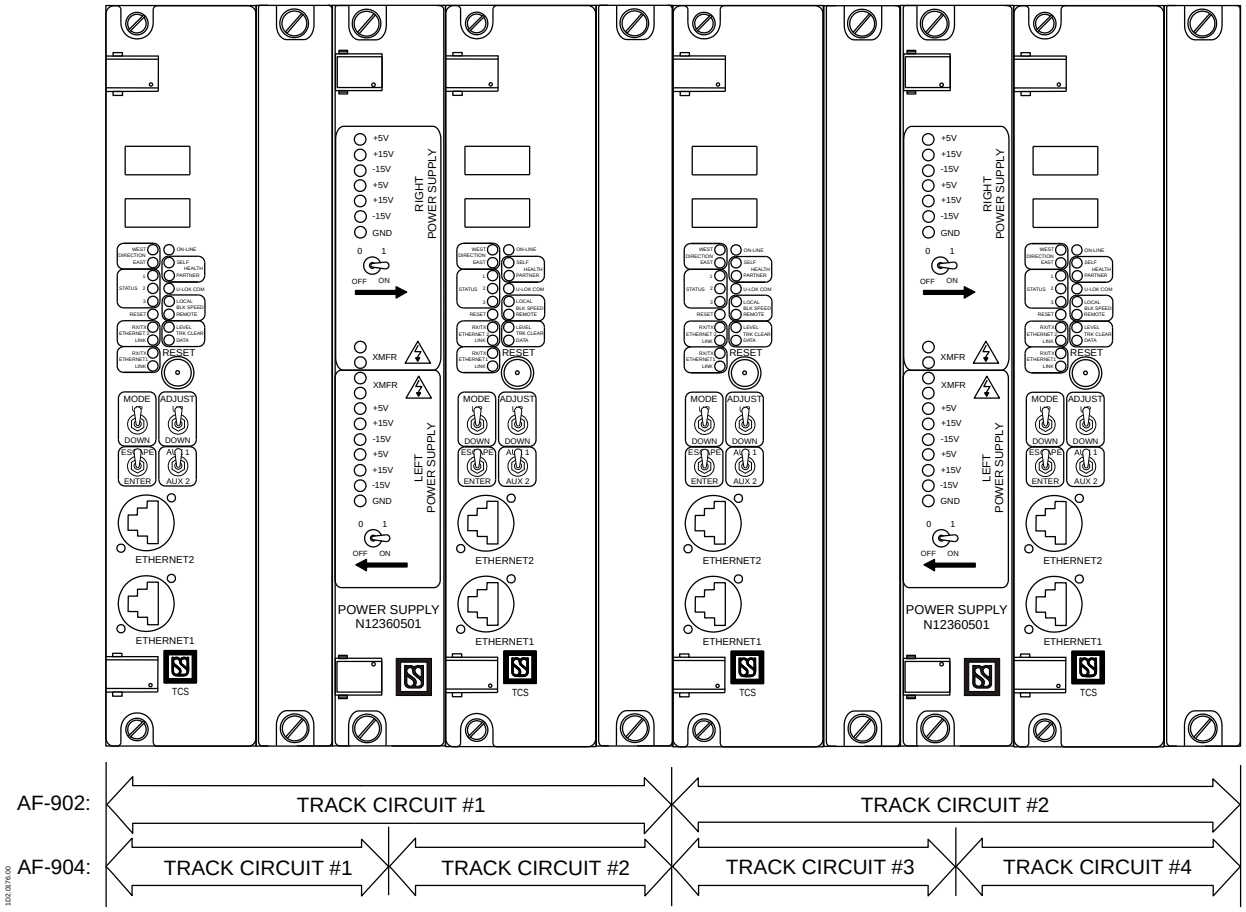


Figure 1-2. AF-902/904 Cardfile Configuration

1.5.2. Track Circuit System (TCS)

Figure 1-3 shows the front panel of the Track Circuit System. The location of these Track Circuit Systems in the cardfile is shown in Figure 1-2. The TCS front panel contains the following:

- Two alphanumeric displays. These are used to monitor the data used in setup and operation of the track circuit. The upper display is red and the lower display is green.
- Four spring loaded, Up/Down toggle switches. These switches are used for inputting data required for setup conditions.
- A system Reset switch.
- 18 LEDs. These supply system information, as described in Section 4.2.1.
- Two Ethernet ports that support:
  - Communications with MICROLOK II's using the MICROLOK Peer Protocol.
  - A user interface to the AF-902/904 system for local operation monitoring, configuration and calibration.
  - Remote AF-902/904 system monitoring using SNMP protocol.

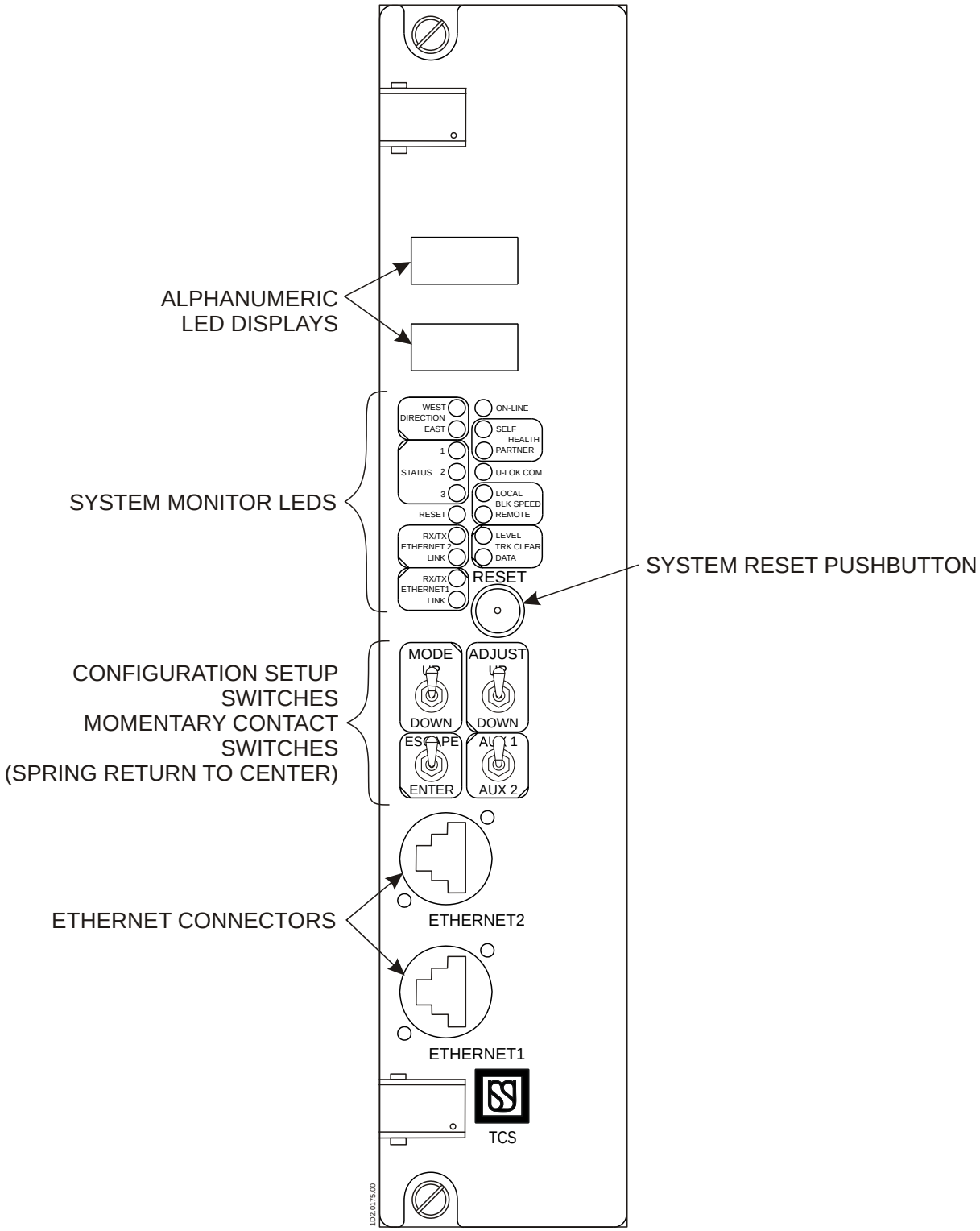


Figure 1-3. Track Circuit System (TCS) Front Panel

1.5.3. Power Supply

Figure 1-4 shows the front panel of the Power Supply. The location of the power supplies in the cardfile is shown in Figure 1-2. Each power supply in the AF-902/904 system provides regulated operating power for two TCS units.

WARNING

Dangerous voltages are exposed when operating the power supply on an extender board. Use extreme caution when working near exposed terminals. Failure to do so could result in serious physical injury or loss of life.

The Power Supply front panel contains the following:

- Six LEDs. Three LEDs monitor left track circuit power and three monitor right track circuit power.
- Two separate power switches. The upper power switch energizes the TCS to the immediate right of the Power Supply and is marked with a right arrow. The lower power switch energizes the TCS to the immediate left of the Power Supply is marked with a left arrow. These switches are locking-lever type switches that must be pulled out to change position.
- Twelve voltage test points. There are four DC and two AC test points for each subsystem supply.

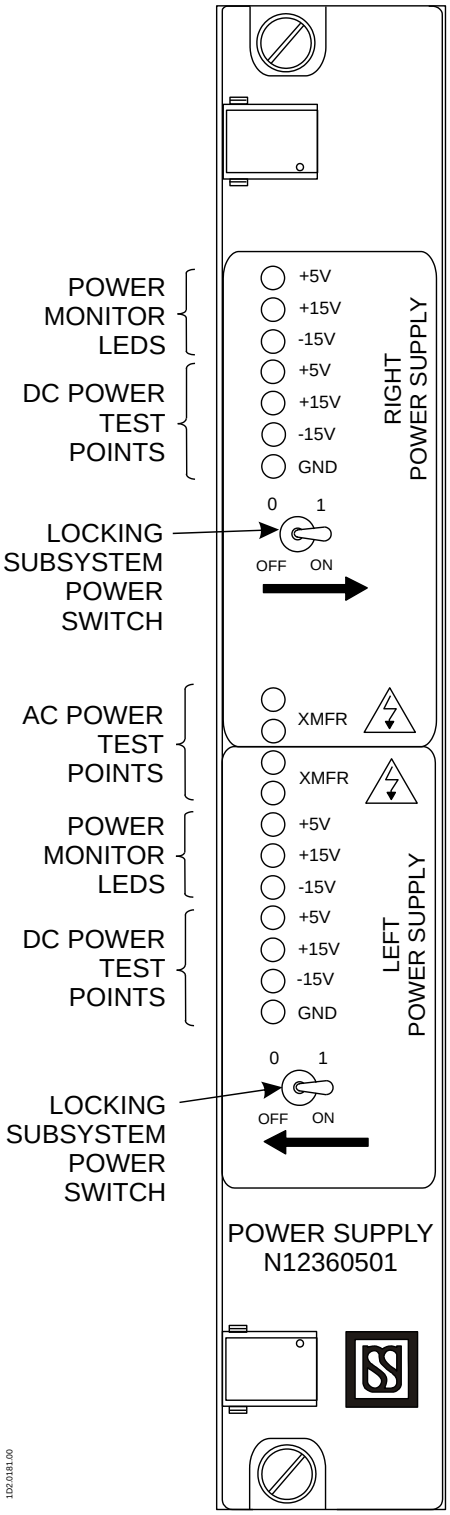


Figure 1-4. AF-902/AF-904 Power Supply

1.5.4. Wayside Components

The required supporting trackside components for the AF-902/904 system are the track coupling units, wire bonds, and track loops.

From the equipment room, track leads of up to several kilometers total loop length connect the trackside coupling units to the direction relays. The track leads are twisted pairs with the intrinsic impedance (Zo) of approximately 100 ohms.

1.5.4.1. Track Coupling Units

Figure 1-7, Figure 1-8, Figure 1-9, and Figure 1-10 show track coupling units for "S", "I", "O", and direct injection track cable bond applications. AF-902/904 coupling units interface the track signals with the cardfile receiver and transmitter circuits. They also provide for tuning to the track circuit carrier frequency. The track coupling units are housed in weather-tight enclosures and consist of two independent and isolated signal coupling circuits. Each circuit has its own transformer and a jumper-adjusted capacitor bank for frequency tuning as required for the track loops.

The dimensions of the track coupling unit are 16"W x 8"H x 10"L (40.64 cm x 20.32 cm x 25.4 cm). The unit can be mounted on the wayside ground base or on a wall.

The coupling units and track circuits are connected through twisted pair #14 cabling that measures a maximum of 6,000 ft. (1,830 m).

Figure 1-5 shows cabling terminal identification (Inductive Coupling), and Figure 1-6 shows the cabling terminal identification (Direct Injection).

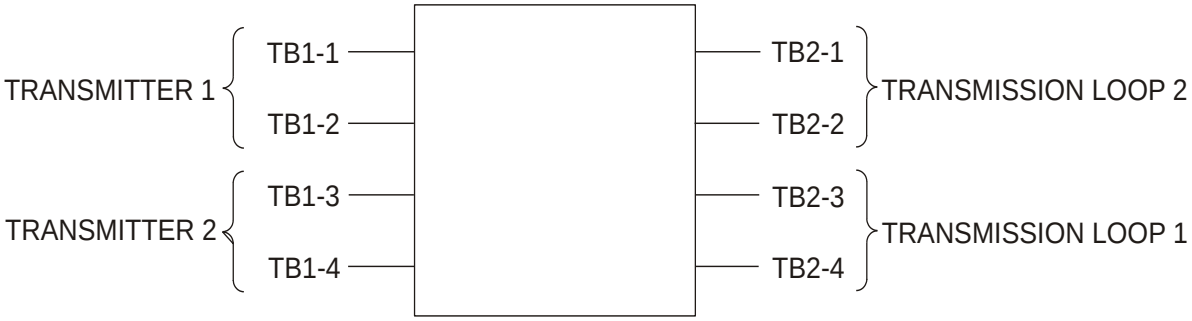


Figure 1-5. Inductive Coupling Unit, Terminal Identification

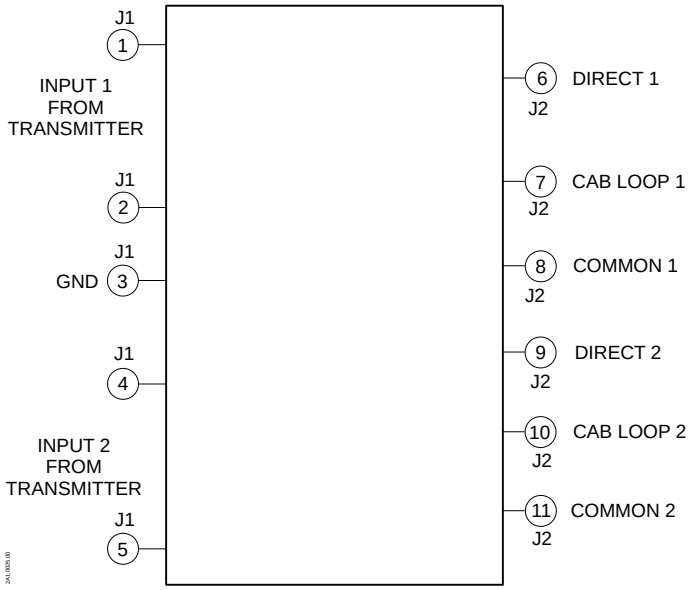


Figure 1-6. Direct Injection Coupling Unit, Terminal Identification

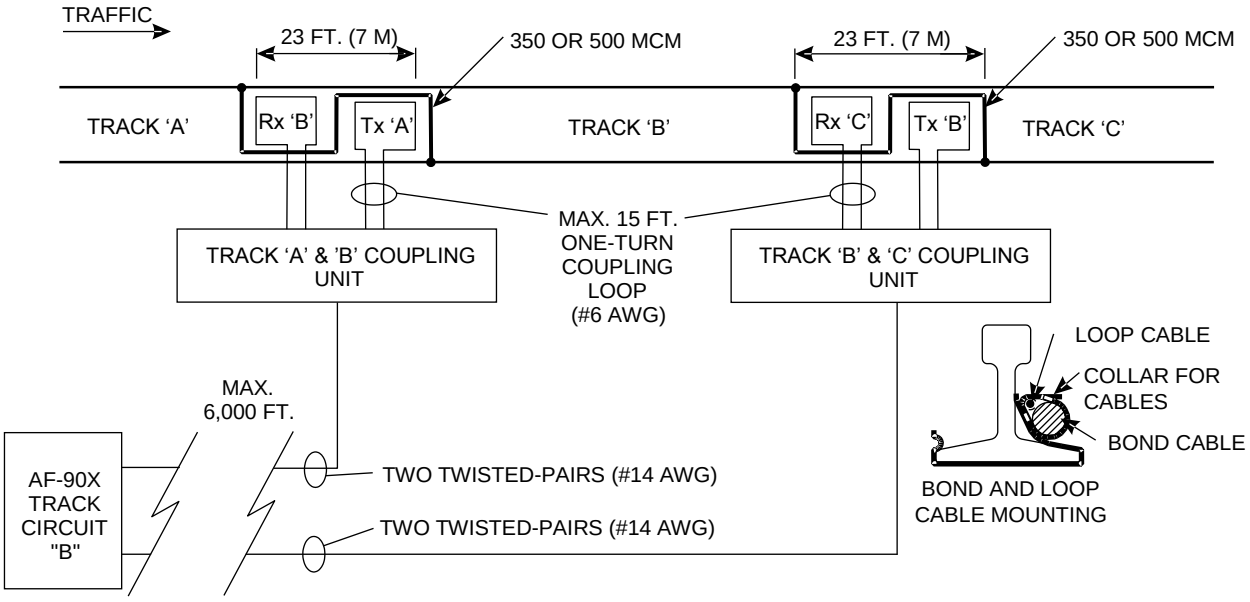


Figure 1-7. Typical "S" Track Cable Bond Application

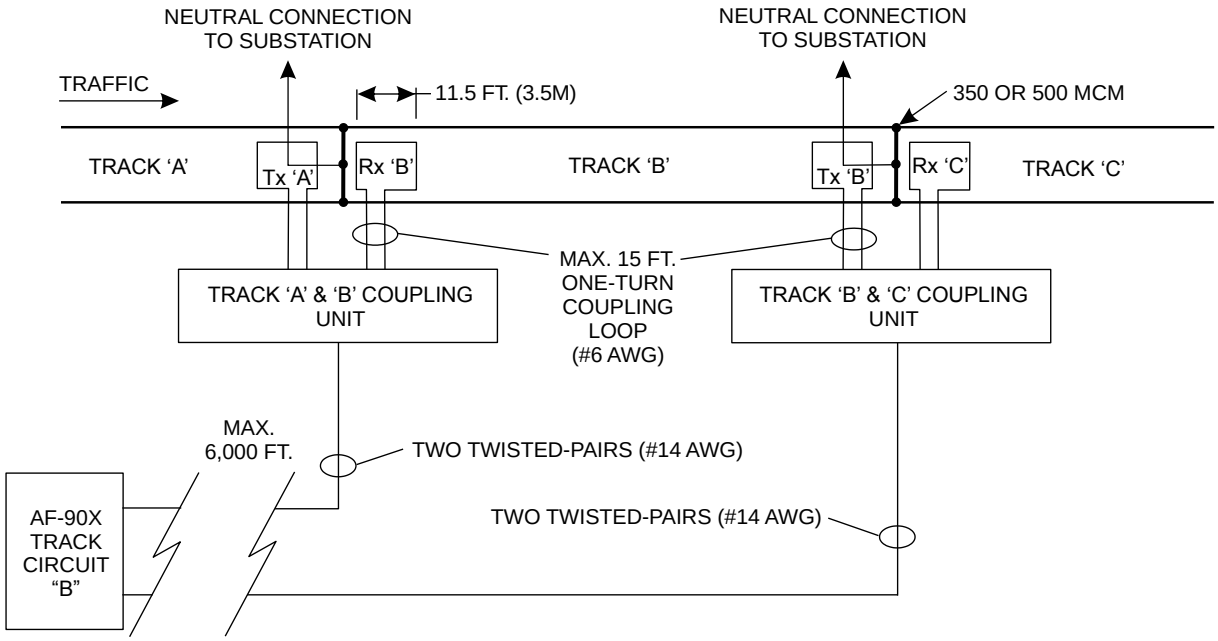


Figure 1-8. Typical "I" Track Cable Bond Application

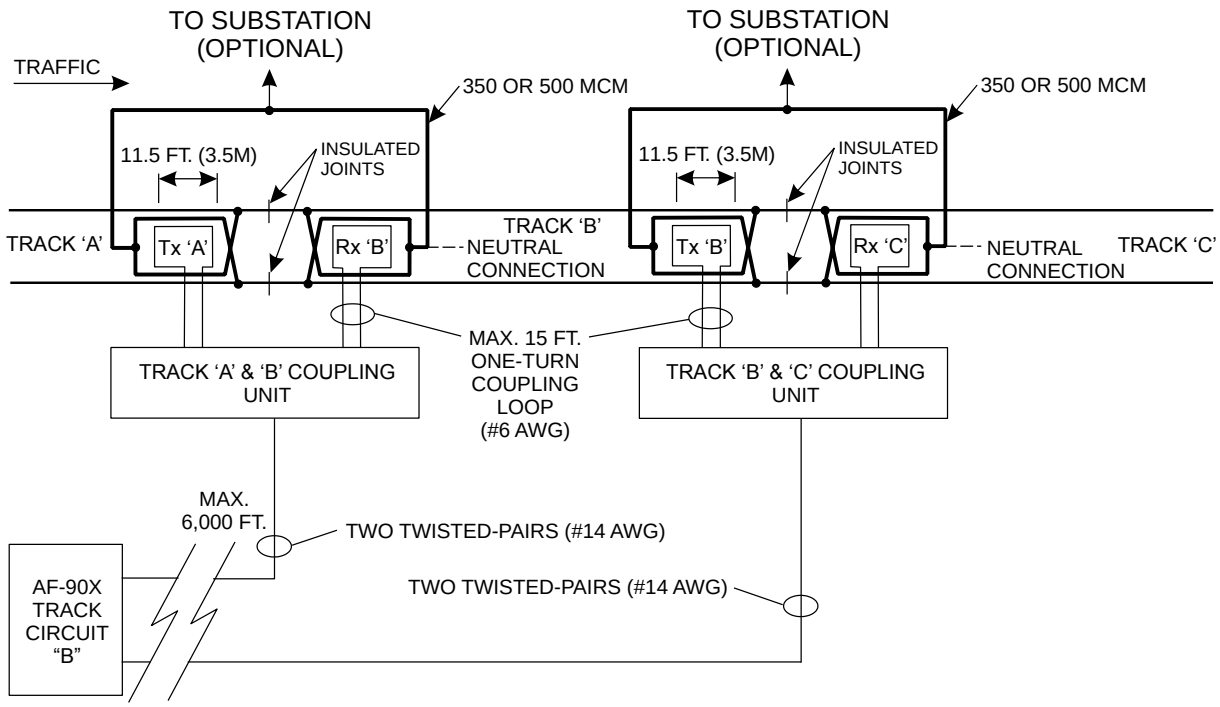


Figure 1-9. Typical "O" Track Cable Bond Application

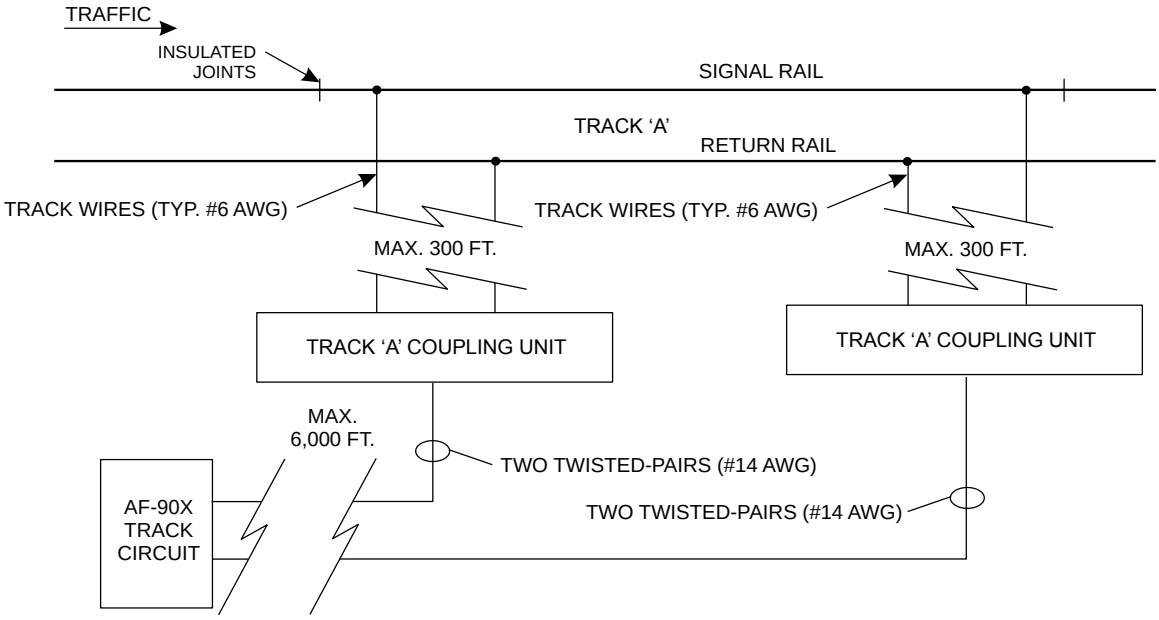


Figure 1-10. Typical Track Cable Bond Application – Direct Injection

1.5.4.2. 350 or 500 MCM Bonds

Signals and messages in the rails are transmitted to and received from the AF-902/904 cardfile via cabling type bonds known as "350MCM" or "500MCM" bonds. The actual bond type that is used for an application depends on the current draw of the train motor. (Although similar, only the 350 MCM bonds are addressed for the purpose of this discussion.) AF-902/904 track coupling units are tuned to the carrier frequency and provide impedance matching to/from the track.

NOTE

Within a limited range there may be several capacitance values that will provide good signal transfer. The capacitance value that provides the best performance at the carrier frequency can usually be found by tuning at a frequency 400 Hz lower than the carrier frequency.

The 350 MCM (Thousand Circular Mils) bond consists of a few meters of 350 MCM cable connected between the two rails in an "S", "I", or "O" shape, with the end of the "S", "I", or "O" bonded to each rail. See Figure 1-7, Figure 1-8, and Figure 1-9. One-turn track loops are inside the upper and lower parts of the "S" and inside the "O" part. As Figure 1-8 shows, the track loops are on both sides of the "I" bond.

"S" and "I" bonds are used in areas where there are no insulated joints that define the track circuit boundaries. "O" bonds are used in areas where an insulated joint is used in each rail to define the track circuit boundaries. The AF-902/904 must be connected so that the track signal is always injected into the track end farthest away from the end that the train is entering. The direction relays mounted in the rear of the cardfile will switch the transmission direction based upon the data in the message received from the vital wayside controller.

1.6. MICROLOK II - AF-902/904 Communications

Communication between the MICROLOK II and AF-902/904 system is conducted using either the legacy RS-485 MICROLOK Serial Protocol or with the new MICROLOK Peer Protocol over an Ethernet network. Each protocol has its own message data format and described in the sections below. The most significant differences are; five bit speed code fields and the optional remote block speed field used only in the Peer Protocol messages.

The part number of a TCS specifies the communication protocol and the encoding of speed and distance codes. The communications protocol and related parameters are pre-programmed and can only be changed by uploading a new Application Data package. The Application Data package can also specify that neither protocol is selected. This option can be used when the AF-902/904 system is used solely for train detection.

1.6.1. RS-485 MICROLOK Serial Protocol

When using the MICROLOK Serial Protocol, the MICROLOK II will periodically transmit data messages to the AF-902/904. The AF-902/904 responds to the MICROLOK II, and logically processes the data before repeatedly transmitting the data to track. This section lists the data fields within these messages.

Details of the message formatting and data encoding for MICROLOK application programming is provided in Appendix A.

1.6.1.1. Serial Message Data Received from Track Microlok II

Signal Message: 24 data bits, 8 header bits, 8 address bits, 24 Cyclic Redundancy Check (CRC) validation bits

Protocol: US&S Vital Serial Link protocol

Data from Track MICROLOK II to AF-902/904 system:

Bits	Name	Function	Description
2	Direction	Traffic/Direction	10 = East 01 = West
3	Next Frequency	Next Frequency	See Appendix A
7	Target Distance to Go	Target Distance to Go	See Appendix A
4	Line Speed	Line Speed	See Appendix A
4	Target Speed	Target Speed	See Appendix A
1	Berthed	Berthed	1 = train not in platform 0 = train in platform
2	Couple/Uncouple	Couple/Uncouple	10 = couple to train 01 = uncouple from train 00 = no action
1	Bifurcation	Bifurcation	1 = point N 0 = point R

1.6.1.2. Serial Message Data Transmitted to Track Microlok II

Bits	Name/Function	Description
1	Block Speed	0 = block speed set 1 = no block speed set
1	Standby Health	0 = Standby unit not available 1 = Standby unit is available
1	Track Occupancy	0 = track occupied 1 = track unoccupied
1	Correspondence	0 = direction not in correspondence 1 = direction is in correspondence
4	Spare	Spare bits that are not used

1.6.1.3. Message Data Transmitted to the Track (Cab Signal)

Signal Message: 37 data bits, 8 header bits, 16 Cyclic Redundancy Check (CRC) validation bits

Protocol: Synchronous, bit oriented (similar to Synchronous Data Link Control [SDLC])

Encoding: NRZI

Bits	Name	Function
12	Track Circuit ID	Identification of present track circuit
1	Primary/Backup	Identification of which controller is providing the message
2	Direction	Train direction of travel
3	Next Frequency	Carrier frequency of the next track circuit
7	Distance to Go	Distance of target speed
4	Line Speed	Maximum speed permitted within track circuit
4	Target Speed	Desired speed at track circuit target
1	Berthed (Door)	OK to open vehicle doors at station
2	Couple/Uncouple	Couple/Uncouple of trains for makeup
1	Bifurcation	Bifurcation

1.6.2. Microlok Peer Protocol

When using the MICROLOK Peer Protocol, the MICROLOK II will periodically transmit data messages to the AF-902/904. The AF-902/904 responds to the MICROLOK II, and logically processes the data before repeatedly transmitting the data to track. This section lists the data fields within these messages.

Details of the message formatting and data encoding for MICROLOK II application programming is provided in Appendix A.

1.6.2.1. Peer Message Data Received from Track Microlok II

Signal Message: 26 data bits, 8 header bits, 8 address bits, 24 Cyclic Redundancy Check (CRC) validation bits

Protocol: MICROLOK Peer Protocol message

Data from Track MICROLOK II to AF-902/904 system:

Bits	Name	Function	Description
2	Direction	Traffic/Direction	10 = East 01 = West
3	Next Frequency	Next Frequency	See Appendix A
7	Target Distance to Go	Target Distance to Go	See Appendix A
5	Line Speed	Line Speed	See Appendix A
5	Target Speed	Target Speed	See Appendix A
1	Berthed	Berthed	1 = train not in platform 0 = train in platform
1	Bifurcation	Bifurcation	1 = point N 0 = point R
2	Couple/Uncouple	Couple/Uncouple	10 = couple to train 01 = uncouple from train 00 = no action
5	Remote Block Speed	Remote Block Speed	See Appendix A

1.6.2.2. Serial and Peer Message Data Transmitted to Track Microlok II

Bits	Name/Function	Description
1	Block Speed	0 = block speed set 1 = no block speed set
1	Standby Health	0 = Standby unit not available 1 = Standby unit is available
1	Track Occupancy	0 = track occupied 1 = track unoccupied
1	Correspondence	0 = direction not in correspondence 1 = direction is in correspondence
4	Spare	Spare bits that are not used

1.6.2.3. Message Data Transmitted to the Track (Cab Signal)

Signal Message: 39 data bits, 8 header bits, 16 Cyclic Redundancy Check (CRC) validation bits

Protocol: Synchronous, bit oriented (similar to Synchronous Data Link Control [SDLC])

Encoding: NRZI

Bits	Name	Function
12	Track Circuit ID	Identification of present track circuit
1	Primary/Backup	Identification of which controller is providing the message
2	Direction	Train direction of travel
3	Next Frequency	Carrier frequency of the next track circuit
7	Distance to Go	Distance of target speed
5	Line Speed	Maximum speed permitted within track circuit
5	Target Speed	Desired speed at track circuit target
1	Berthed (Door)	OK to open vehicle doors at station
1	Bifurcation	Bifurcation
2	Couple/Uncouple	Couple/Uncouple of trains for makeup

1.7. Specifications

1.7.1. Track Circuit

Track Circuit Length: 1,000 ft. (305 m) maximum; 65 ft. (19.812 m) minimum

Shunt Sensitivity: < 0.25 ohms

Pre/Post Shunting: < 5.0 ft (1.524 m)

1.7.2. Cardfile

Power Input: 115 VAC ± 10% at 50/60 Hz (50 watts per track circuit)

Input Power Protection: 10 amp fuse

Environmental: -25°C to 70°C with 95% humidity (non-condensing)

1.7.3. Coupling Unit

Coupling Feed: 6,000 ft. (1,800 m) maximum, with twisted pair of #14 AWG

Coupling Unit to Loop Feed: < 15.0 ft (5 m) #14 AWG

Tuned Circuit: Connected to one-turn loop

1.7.4. 350 or 500 MCM Bond

Cable Bond: 350 or 500 MCM conductive

Signal exchange: Inductive Coupling

Impedance: 1.0 ohm (approximately)

Cab signal current: 105 milliamps at 9.5 kHz (see Table 6-11)

1.8. References

The following can be used as references:

- ASTS USA Service Manual 8054 - Train to Wayside Communications (TWC) System Wayside Equipment - Operation and Maintenance Service Manual
- Refer to Specific site plans for detailed installation data and track coupling requirements.

2. TYPICAL APPLICATIONS

This section provides an overview of the AF-902/904 system and its functional responsibilities within the wayside application.

NOTE

For assistance regarding non-typical track circuits that are not described in this manual, contact the Rail Team (see Section 13).

The AF-902/904 system has been designed as a communications interface between the interlocking logic, processed by MICROLOK II units, and the equipment on the vehicle used for controlling the movement and speed of a train. The AF-902/904 equipment takes serial input from MICROLOK II, adds local track identification information, and transmits this combined data to the train through the rails. The interface to MICROLOK II is a bi-directional serial link or Ethernet link. The communications interface to the train is a one-way link where the car only receives information.

The AF-902/904 equipment transmits, into one end of the track circuit, information such as track circuit ID, target speed, line speed, distance-to-go, berthed, direction, next cab carrier frequency, coupling/uncoupling, and bifurcation. It also monitors the other end of the track circuit to detect train occupancy. Vital wayside logic is typically performed by the MICROLOK II system. A typical wayside system is illustrated in Figure 1-1.

AF-902/904 circuits are used for both train detection and cab signaling. Crossovers and turnouts use the power frequency track circuits for train detection and AF-902/904 cab loops for data communications to the carborne ATC system. PF track circuits are described in ASTS USA Service Manual 6087.

The AF-902/904 signals are coupled into the track via S bonds, O bonds, I bonds or direct injection as described in Section 1.5.4.1.

When the AF-902/904 receiver senses a low amplitude or incorrect data, as compared to the predetermined threshold level and track ID, it indicates that the track circuit is shunted by an occupying vehicle.

As the vehicle travels from track circuit to track circuit, the car borne ATC system tunes a filter on the vehicle receiver to the correct next frequency, allowing the vehicle to receive the data for the correct track frequency only.

The vehicle's ATP subsystem decodes the vital track data to perform the ATP functions.

2.1. Mainline Track Circuits

The AF-902/904 system is designed for simple, highly-reliable track interface applications using jointless track circuits.

The carrier signals and modulated data signals are coupled to the rails via the 350 or 500 MCM bond and coupling unit at each end of the track circuit. The amplitude of the carrier and the track ID data signals is used to determine track occupancy. The modulated FSK data signal is used to transmit vital and non-vital data to the vehicle.

2.1.1. Track Circuit ID and Cab Signal Transmission

As the train travels from track circuit to track circuit within the mainline territory (station-to-station), track occupancy and isolation of commands between track circuits is accomplished by alternating eight available data carrier frequencies. Frequencies range from 9.5 to 16.5 kHz in 1 kHz steps and are numbered F0 through F7. Three frequencies (F1, F3, and F5) are assigned to westbound or northbound track circuits, and three frequencies (F2, F4, and F6) go eastbound or southbound. The two remaining frequencies (F0 and F7) are usually used in special work areas.

Specifically, the layout of the mainline track circuits should follow the two three-frequency rotations shown in Figure 2-1. If it is not possible to separate two track circuits of the same carrier frequency by two intervening track circuits, then separation by one intervening track circuit plus a set of insulated joints is acceptable.

As shown in Figure 2-1, carrier frequency F1 contains data that informs the train of the next cab signal frequency (F3). Onboard the train, one receiver is tuned to F1 and the other to F3. As the train approaches the 350 or 500 MCM bond, signal F1 drops out. Once valid data and level is detected on F3, the vehicle ignores the data arriving from the old F1 receiver. The new data is then decoded and the vehicle logic retunes the receiving filter (previously tuned to F1) to the next cab signal frequency in the sequence of track circuit frequencies (refer to Figure 2-2).

The track circuit is arranged so that the train is always heading toward the transmitter. This is controlled by the two assigned Direction Control bits within the message received from the MICROLOK II.

Each wayside track circuit continuously transmits digitally-formatted data to the vehicle using FSK modulation. The track MICROLOK II determines most of the information in the data bits and passes this data on to each AF-902/904 track circuit, via vital serial or Ethernet communications links, where the data is logically processed and encoded for the track message.

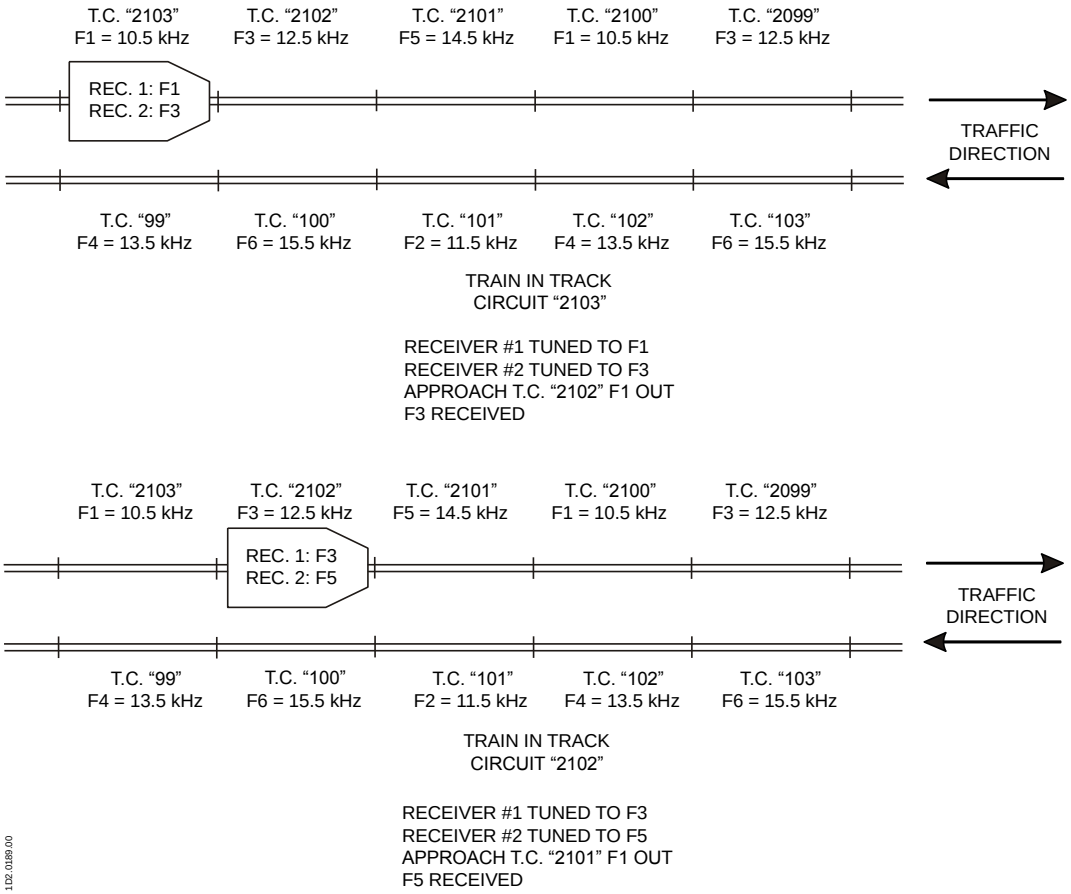


Figure 2-1. Application of Cab Signal Frequencies to Track Circuits

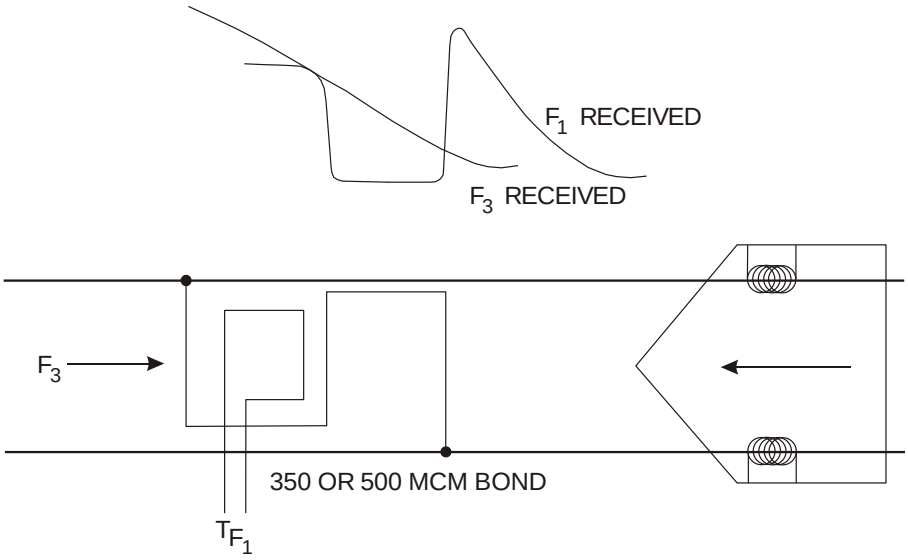


Figure 2-2. Cab Signal Sequencing

The first eight bits are used for synchronizing the onboard decode function. The next 36 or 38 bits contain train control data. The last 16 bits of the message are the CRC bits for error detection. Message configuration and bit assignments are described in Section 3.

Two types of speed restrictions are initiated by the ATC system: block speed restrictions and zone speed restrictions. Block speed restrictions are selected by the Maintainer for each AF-902/904 track circuit. Zone speed restrictions limit the target speed for a control line. The AF-902/904 system enables the selection of the maximum line speed and target speed permitted to be transmitted by a track circuit.

The Distance-to-Go bits represent the distance to the target speed, which is the desired speed of the train at the end of the control line.

Train detection and signal communications are similar to those of the mainline continuous rail territory, with the exception of the Berthed recognition bits contained in the message.

2.2. Yard Track Circuits

In addition to their use for station-to-station operations, the AF-902/904 track circuits are also used in storage yards, which are characterized by short track circuits and slow train movement. Here, the system allows automatic movement of cars for the purpose of making up new train configurations.

Yard track circuits use the same carrier frequency assignments and rotations as the mainline track circuits: F1, F3, and F5 for west/north circuits and F2, F4, and F6 for east/south circuits. However, for yard track circuits, it is only necessary to separate two track circuits of the same carrier frequency by one intervening track circuit. Figure 2-3 shows this configuration.

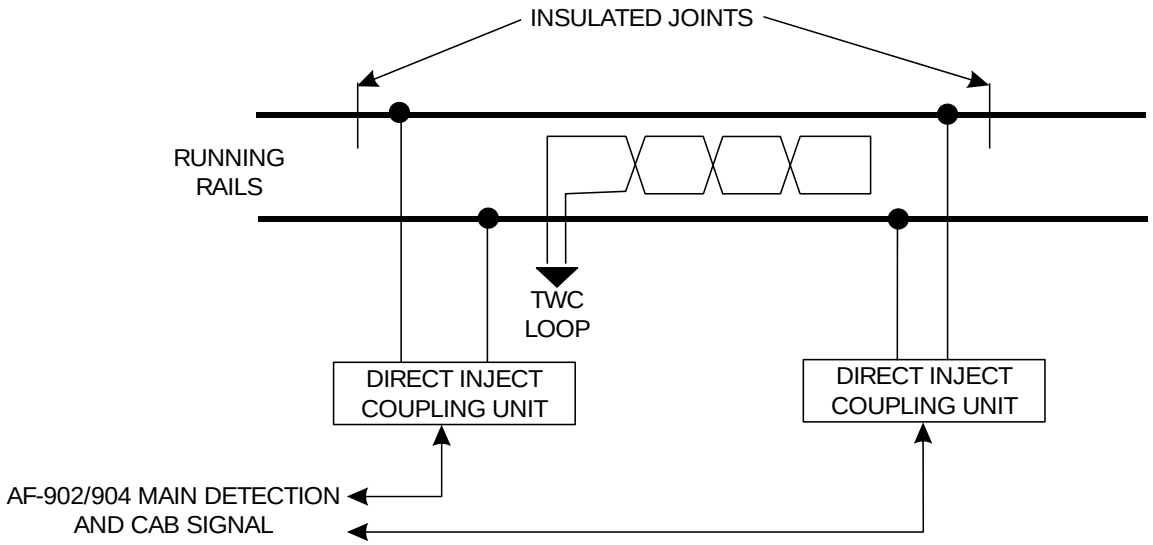


Figure 2-3. Single Rail Track Circuit

The cab signal is injected into the rails via direct-inject connection of the coupling unit to the rails (See Figure 2-6). The direct injection method is used because only one rail of the track circuit contains insulated joints. "S" bond, "O" bond, "I" bond coupling methods will not function in areas where one rail of the track circuits are tied together. Vital commands such as speed, coupling/uncoupling, and direction are transmitted to the vehicle via the cab signaling system. Non-vital, bi-directional data, including vehicle health information, diagnostics, and testing commands, is transmitted via the train-to-wayside communication system.

2.3. Cab-Only Transmission in Crossovers

A typical crossover arrangement of a cab-only transmission loop is shown in Figure 2-4. A transmission loop is installed within the rails of the crossover. The loop is transposed approximately every 13 feet (4 meters) to prevent induced electrical interference between the cab loop and the rails. The loop is connected to a coupling unit, which in turn is connected to the output of one of the two transmitter groups. In these crossovers, train detection is done via standard power frequency track circuits.

Note that in certain applications, crossovers may also be controlled by AF-902/904 equipment in a direct injection configuration, as shown in Figure 2-3.

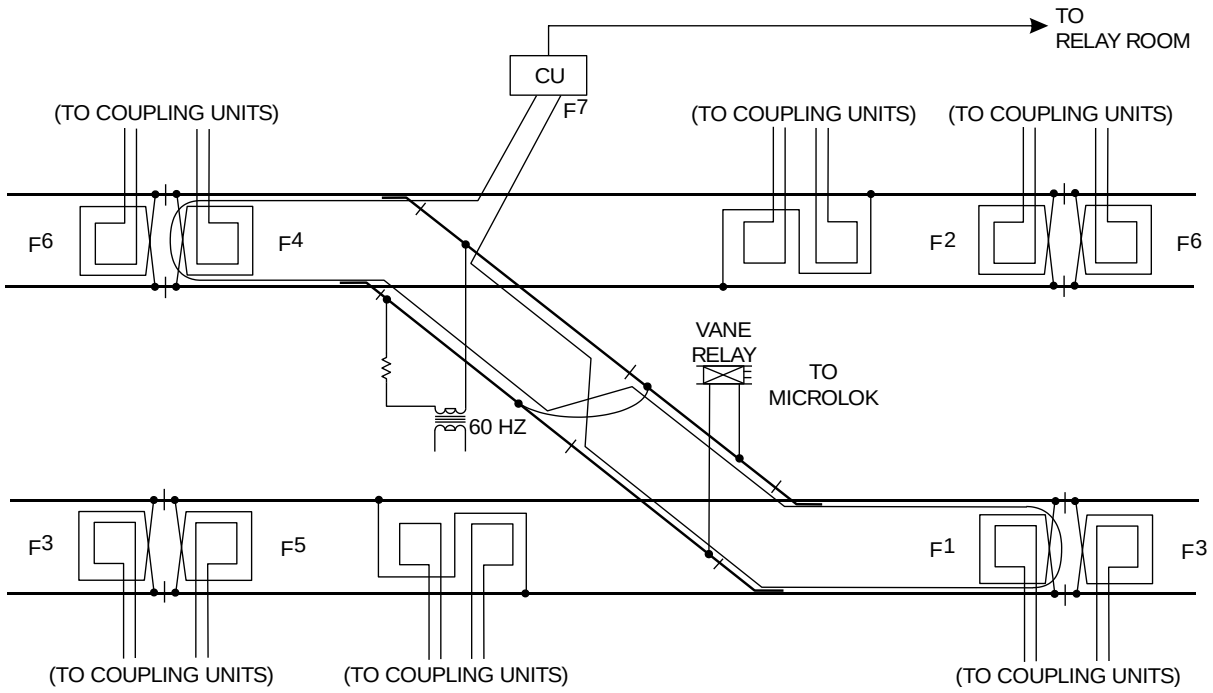


Figure 2-4. Typical Interlocking Cab-Only Transmission Loop

2.4. System Connection Diagrams

The AF-902 cardfile is a self-contained unit that consists of the Primary track circuit (A) and its redundant Backup track circuit (B). The AF-904 cardfile contains four independent track circuits.

Figure 2-5 shows cabling terminal identification (Inductive Coupling), and Figure 2-6 shows the cabling terminal identification (Direct Injection).

Figure 2-7 shows the location of the jumpers on the AF-902 motherboard that connect the terminating resistor(s) across the Vital Parallel Output (VPO) when it is not used. There is one jumper and terminating resistor for each track circuit.

Figure 2-8 shows the location of the jumpers and terminating resistors on the AF-904 motherboard. There is one jumper and terminating resistor for each track circuit.

Figure 2-9 illustrates typical wiring connections for Track Circuits1 and 2. Figure 2-10shows the typical serial link connections between the MICROLOK II ports and the AF-902 connectors.

Figure 2-11 depicts the typical connections between the AF-904 connectors and track circuits 1, 2, 3, and 4.

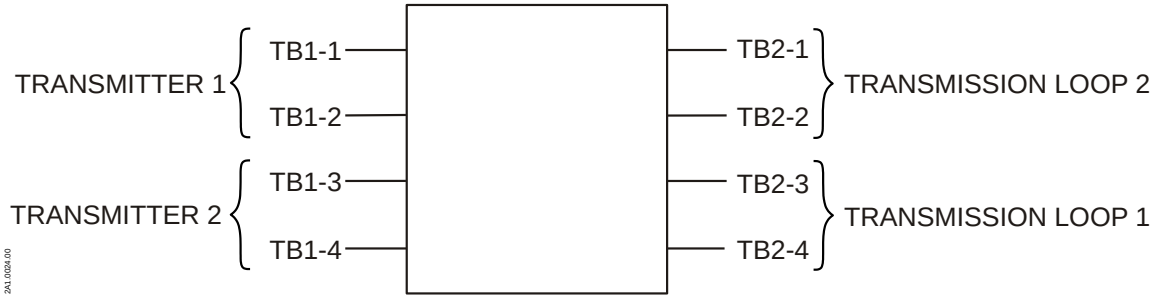


Figure 2-5. Inductive Coupling Unit, Terminal Identification

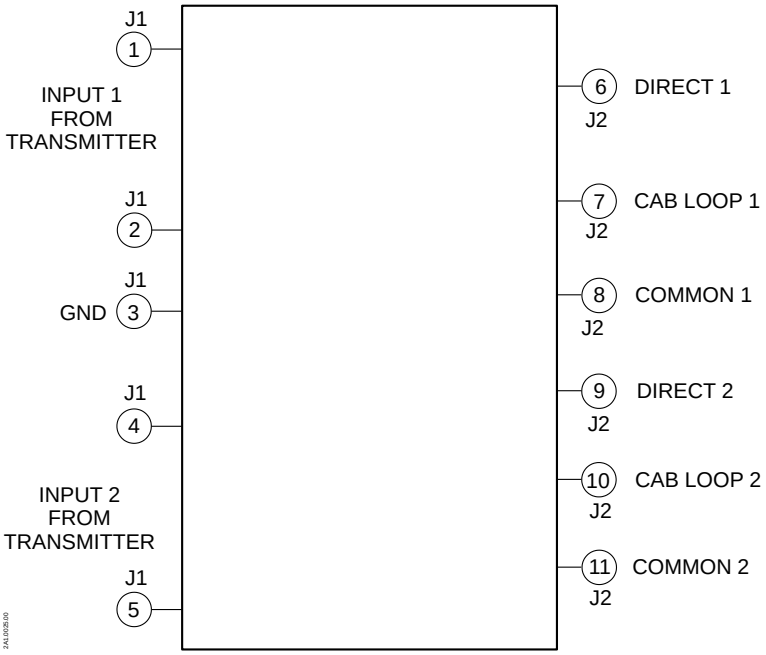


Figure 2-6. Direct Injection Coupling Unit, Terminal Identification

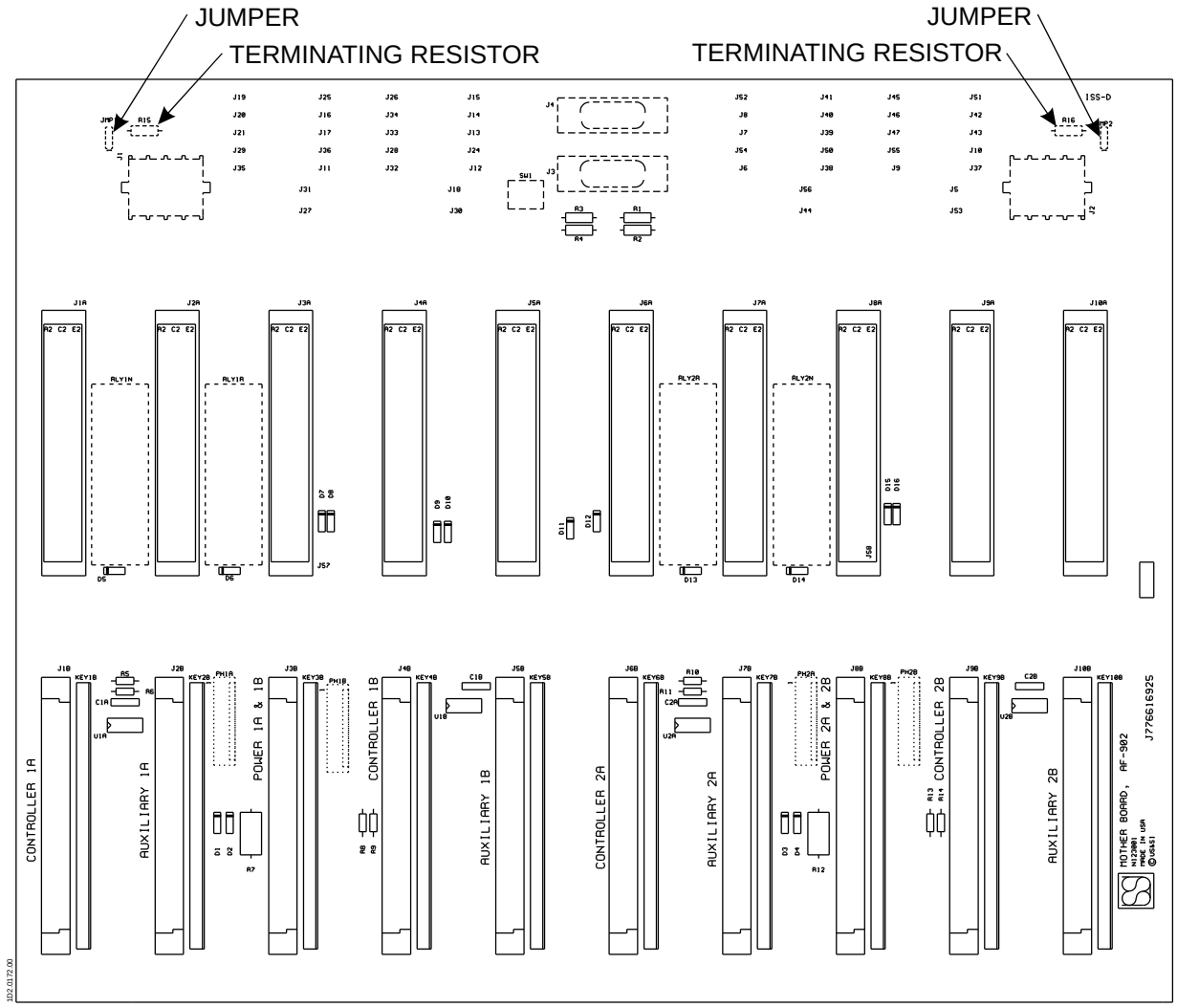


Figure 2-7. AFO-902 Motherboard VPO Jumpers and Terminating Resistors

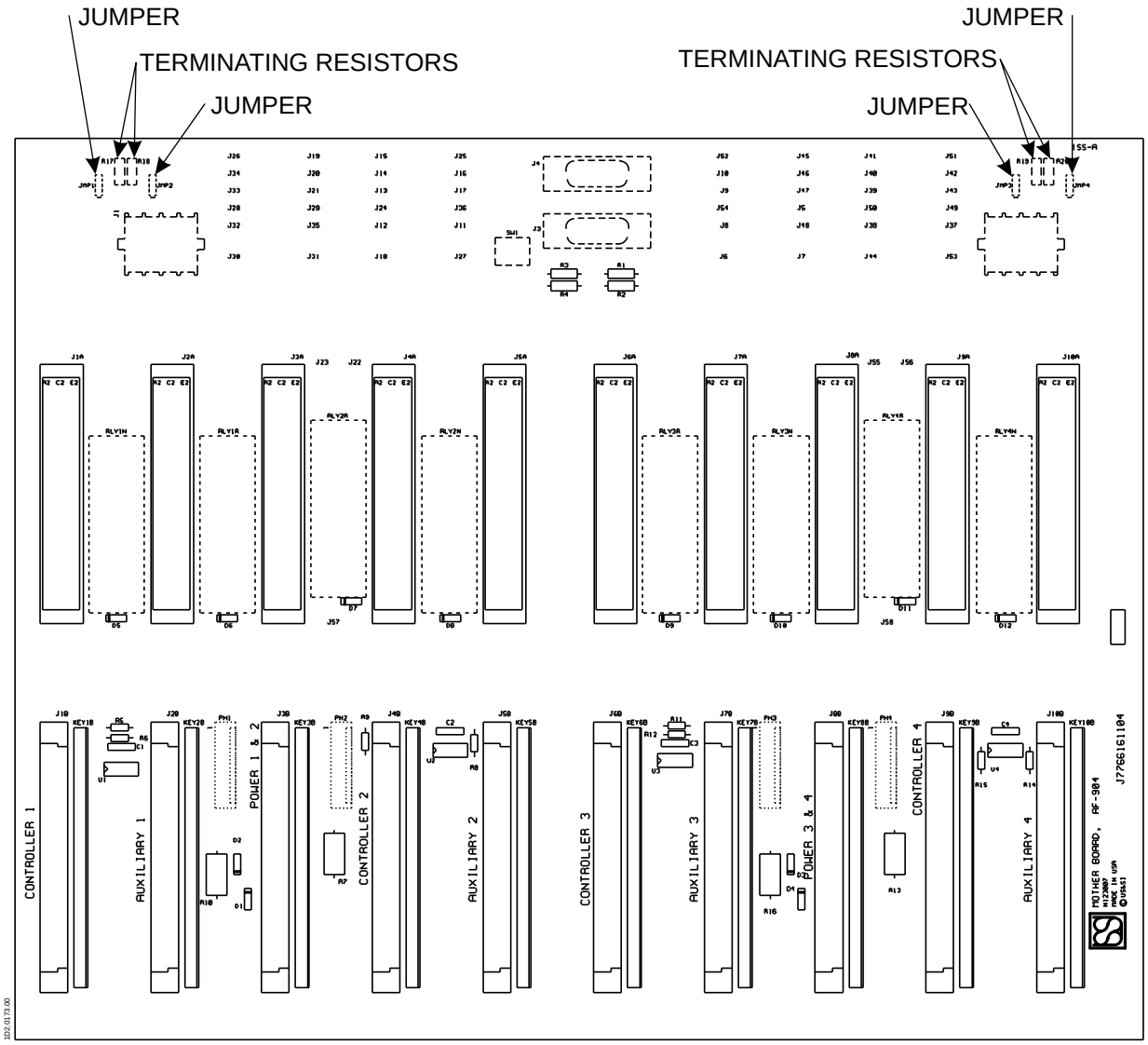


Figure 2-8. AF-904 Motherboard VPO Jumper and Terminating Resistors Detail

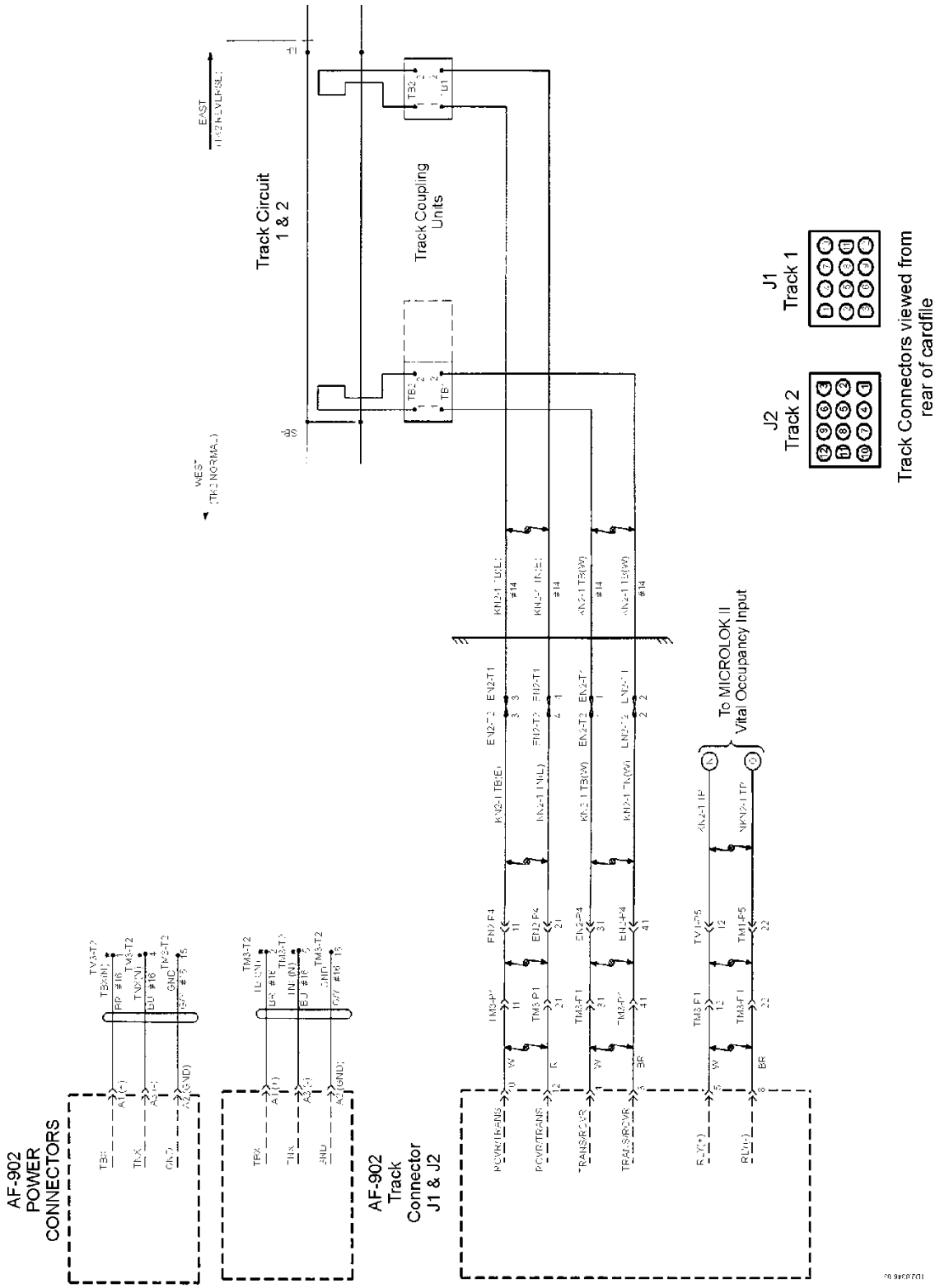


Figure 2-9. AF-902 Track and AC Connectors and Typical Wiring

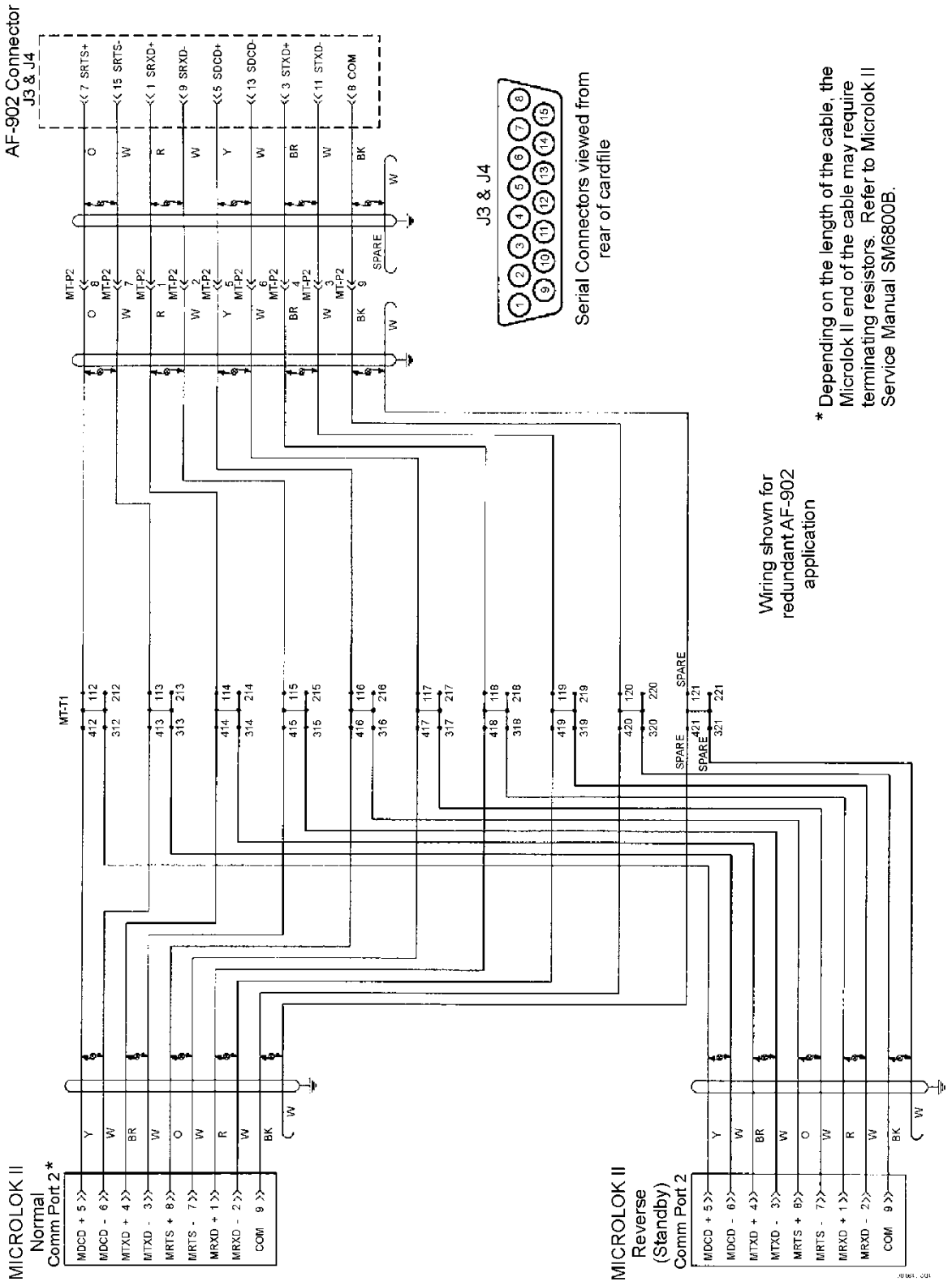


Figure 2-10. AF-902 Typical Serial Link Connections

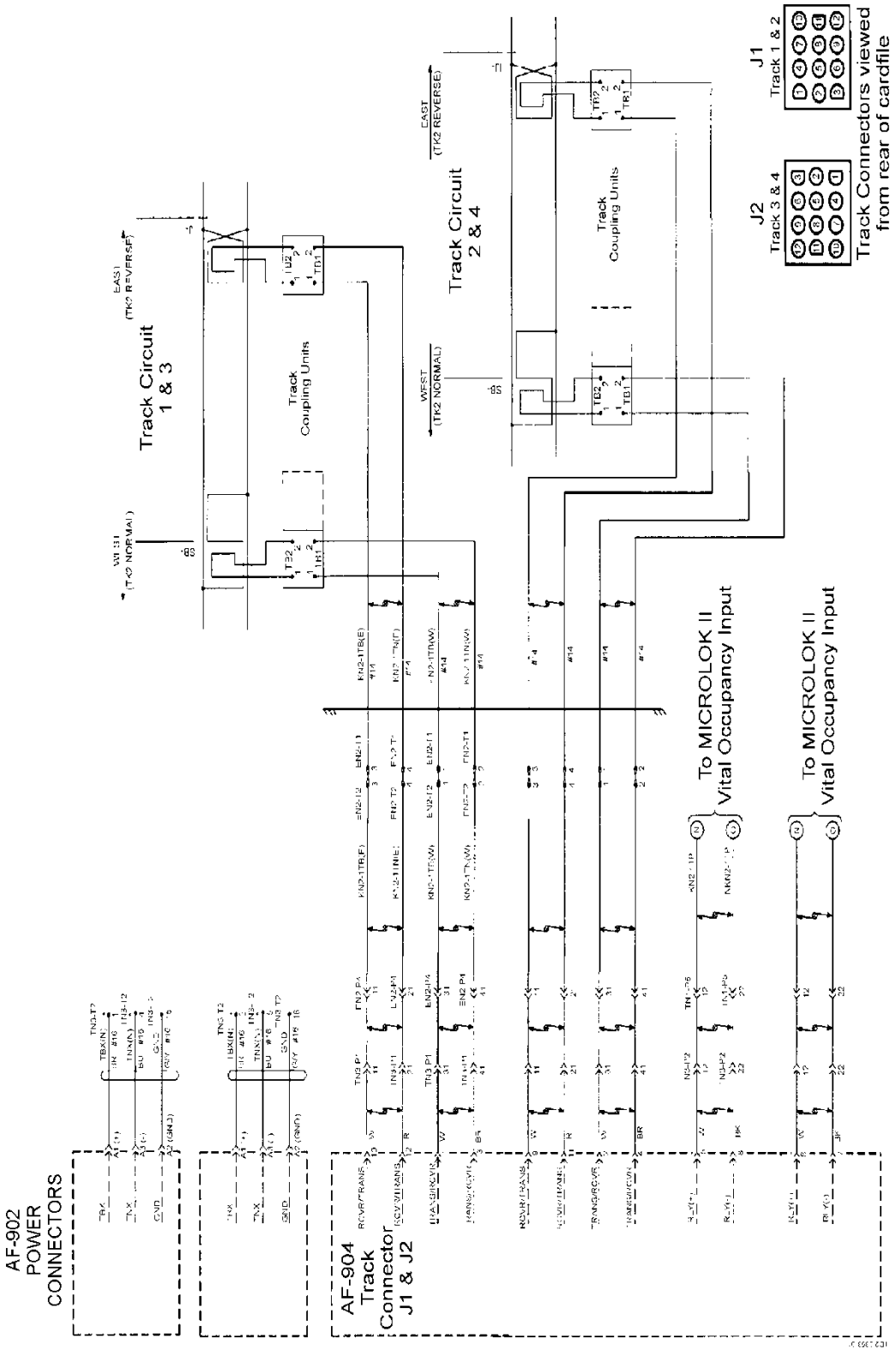


Figure 2-11. AF-904 Track and AC Connections and Typical Wiring

3. FUNCTIONAL DESCRIPTION

3.1. Introduction

The TCS receives vital data from the Track MICROLOK II, processes message speed and distance data, adds local track circuit identification, and formats a track message. This message is then sent to the train via the transmitter-end track coupling unit, bond and rail. The TCS monitors the track signal via the receiver-end bond track coupling unit, to detect the presence of a train in the track circuit. The TCS reports track circuit track occupancy to the MICROLOK II Vital Interlocking Controller. The data message sent to MICROLOK II also contains the status of the partner system health, direction relay correspondence, and local speed reductions. The message to MICROLOK II is returned over the Ethernet or RS-485 data link. Occupancy status is also sent to the MICORLOK II by a Vital Parallel Output (VPO) line.

3.2. Wayside to Train Message Processing

3.2.1. Message Data Processing

When a signal is received from MICROLOK II, the TCS extracts the data from the MICROLOK Serial Protocol or MICROLOK Peer Protocol message. The TCS vitally processes the message data with past message data, and local track data stored in its Electrically Erasable Programmable Read Only Memory (EEPROM).

Each of the four TCS's in a cardfile has its own EEPROM. The EEPROM data used in the processing includes the unique 12-bit Track I.D. number, and possibly a local block speed restriction. The EEPROM also stores configuration information for the unit, such as the MICROLOK II slave address, I.P. addresses, carrier frequency, track circuit threshold voltages, and other non-volatile information needed to operate the AF-902/904 system.

The AF-902/904 system compares the local and remote block speeds if set, to the MICROLOK II message's Line Speed and Target Speed. If the local or remote block speed is slower than the message Line or Target Speed then the slower speed will be transmitted to the track as the Line and/or Target Speed. If the local or remote block speed is greater than that commanded by MICROLOK II, or is not set, the MICROLOK II message's speed commands will be transmitted to the track.

3.2.2. Equipment Room to Rails

From the relay/equipment room, track leads of up to several kilometers total loop length (3 kilometers of #10 gauge wire) connect the trackside coupling units to the direction relays. The track leads are twisted pairs with intrinsic impedance (Zo) of approximately 100 ohms. The coupling units are housed in weather tight enclosures and consist of two totally independent and isolated coupling circuits. Each circuit has its own transformer and capacitor bank. The transformer steps down the high voltage on the leads from the relay room to a low voltage suitable for driving the single turn track loop. The capacitors are jumper-selected to tune the track loop.

Tuning raises the reactance of the track loop to the selected carrier frequency. This raises transmitter efficiency since smaller currents are required to flow in the long track leads.

Likewise, when a track loop has been selected to be a receiver, the low voltage from the track loop is stepped up to drive the leads back to the relay room. The tuning of the track loop provides a small increase in received signal strength. Due to the differences in transmitter and receiver impedance, the coupling unit is adjusted, to provide some benefit to both transmitter and receiver. The tuning is necessarily very broad and does not result in any appreciable frequency selectivity between the jointless track circuits.

The AF-902/904 system does not use a conventional impedance bond. Instead, a few meters of 350 or 500 MCM cable are connected between the two rails in an "S" shape, with an end of the "S" bonded to each rail. Single turn track loops are mounted inside of the upper and lower parts of the "S." Currents circulating in the transmitting track loop are induced into the "S" and onto the track. Likewise, currents from the track circulate in the "S" and are induced into the receiving track loop. This type of bond has a strong directionality, with the ratio of the length to the width of the "S" determining the "directivity" (like the front-to-back ratio on an RF directional antenna). The track loop that transmits or receives is determined by the direction relays on the rear of the cardfile.

3.3. Train Detection

Each AF-902/904 system vitally monitors the status of a single track circuit. The audio frequency carrier that is transmitted at one end of the track circuit and received at the other is used not only for the digital cab signal data, but also for train detection. The carrier level and the digital message are monitored by the receiver to determine track occupancy.

When a train shunts the rails of the monitored track circuit, the signal is blocked. This condition is recognized by the receiving AF-902/904 circuits as a drop below a preset signal threshold and is reported to the associated interlocking MICROLOK II system as an occupied circuit. The AF-902/904 displays the track signal as a percentage of the shunt threshold. Signal levels at or below 100% indicate an occupied track circuit. An unoccupied track circuit is nominally 162% of shunt. This value will normally drift up and down as ballast conditions change.

Communications of track occupancy are sent to the vital MICROLOK II using the MICROLOK Peer message over the Ethernet link or a MICROLOK Serial Protocol message over a RS-485 link. Occupancy is also indicated on the DC voltage vital parallel output. This output can be connected to a MICROLOK II Vital Input for faster occupancy state indication. While the shunting train bridges adjacent track circuits, both are reported as occupied. When the train clears a track circuit, the received signal threshold is restored and the AF-902/904 system responds accordingly.

From the receive cable, the returning signal passes through an internal disconnect relay before being applied to the receiver transformer. The receiver transformer has five taps. These taps allowed the older AF-902/904 equipment to be adjusted for different operating conditions, such as track lead length, direct injection vs. bond injection, and loop driving without a bond. The AF902/904 Generation II system incorporates a self-adjusting receiver gain and requires that the receiver tap on the rack always be set to the "2" position.

3.4. Fail-Over

The left TCS of each AF-902 track circuit is called the Primary, and the right pair is called the Backup. These terms refer to the physical placement of the TCS. The unit that is operating the track circuit is called the On-Line unit and the other unit is called the Standby or Off-Line unit. This logical distinction is needed because a failed or powered-off Primary unit could be replaced and/or powered up without it becoming the On-Line unit. The Primary unit would remain the Standby unit until the power is cycled to both units or the Backup unit fails or is reset.

Each AF-902/904 TCS must pass its own continuous set of internal diagnostics. In AF-902 systems, if the On-Line track circuit controller fails, the Standby track circuit automatically switches into operation.

3.5. Microlok II Communications Link Monitoring

The AF-902/904 system continuously monitors the status of the communications with the MICROLOK II. The following is a set of possible fault conditions that could be detected by an AF-902/904 system. The faults pertain to master messages and peer messages sent by the MICROLOK II to the AF-902/904 system.

Timeouts: If an AF-902/904 system does not receive a valid message from the MICROLOK II in 3 seconds, it will declare the link to be down.

CRC Mismatch: If a CRC does not match for a message received from MICROLOK II, the AF-902/904 system will discard the invalid message.

Incorrect Length: If a response message from the MICROLOK II is either too long or too short because of any data bytes or CRC mismatch, the incomplete message will be discarded.

No Acknowledgment: If peer message acknowledgments are not received by the AF-902/904 system from MICROLOK II, the AF-902/904 system will declare the link to be down.

4. USER INTERFACE

4.1. Integrated Web Server

The TCS front panel of the AF-902/904 system contains two Ethernet ports. Each of these ports provide three communications features: MICROLOK Peer Protocol communications between the AF-902/904 and the MICROLOK II, remote monitoring using SNMP, and a user interface web server.

The web server provides the maintainer a convenient way to monitor system operation and to configure and calibrate AF-902/904 system operational parameters using Microsoft's Internet Explorer. All front panel operations can be accomplished through this web interface. The web interface provides five primary pages. These pages are selected by clicking on one of the five tabs on the upper right area of the main page.

4.1.1. View Current Data Page

The View Current Data page displays dynamic system data and is the AF-902/904's home page. This page shows the data contained in the messages between the MICROLOK II and the AF-902/904 and the track message. The data is displayed in decoded values as well as the binary bit patterns for the data fields. The current shunt level and the track's signal variance is displayed at the bottom of the page. Variance is derived from the amplitude difference between the track signals mark and space frequencies. A small variance indicates that the coupling unit is well tuned.

4.1.2. View Configuration Page

The View Configuration page displays static system configuration parameters. The parameters associated with the communications to the MICROLOK II, Ethernet port addresses, SNMP configuration, and track circuit identification and calibration setting are displayed. The AF-902/904 system software components versions are also displayed.

4.1.3. View Events Page

The View Events page provides a display of the log of AF-902/904 system events, warnings and critical errors. This data aids in diagnosing a malfunctioning system.

The user is given the option of setting a logging threshold for events. More detailed events are logged at the higher thresholds.

- Logging Threshold 2: The TCS will only log critical system errors and warnings
- Logging Threshold 5: Critical system errors, warnings, and informational events will be logged
- Logging Threshold 8: Additional operational information details will be logged such as changes in message data.

- Logging Threshold 15: This level is designed to be used in detailed troubleshooting of difficult problems with the guidance of Ansaldo Technical Support. It displays many cryptic messages of system diagnostic tests.

Logging Threshold 2 or 5 should be used for normal operation. Setting the threshold too high can make it difficult to identify system faults among the lesser important informational events. The time associated with each event is the time from the last reset.

4.1.4. Front Panel View Page

The Front Panel View page shows all of the data present on the front panel discrete LEDs and the meaning of the LED states.

4.1.5. Setup

The Setup page provides password-protected entry to the pages used to configure and calibrate an AF-902/904 system. Entry and detailed use of the Setup Mode pages are described in Section 6 of this manual.

4.2. TCS Front Panel Operation

The front panel menu system of the AF-902/904 unit can also be used to modify and display vital and non-vital system parameters and to calibrate and configure the system. It is provided for compatibility with older AF-902/904 systems. Any operator can access any menu function except for the configuration functions, which can be accessed only by authorized operators.

4.2.1. Front Panel Displays

The menu control system consists of two, four-character alphanumeric scrolling displays. Discrete LEDs provide additional system operational mode and status information as listed in Table 4-1. Figure 4-1 shows the switches and displays as well as the corresponding names and identification.

Table 4-1. TCS LED Indications

Group	LED	On	Off	Flashing
DIRECTION	W	West/North Normal relay picked	West/North Normal relay dropped	West/North Normal relay picked Track Shunted
	E	East/South Reverse relay picked	East/South Reverse relay dropped	East/South Reverse relay picked Track Shunted
STATUS	1	Failover link good	Failover link bad	N/A
	2	Setup Mode	Normal mode vital processors are healthy	Vital processors have detected a warning or error condition
	3	For Future Use	For Future Use	For Future Use
RESET	RESET	TCS is Resetting	TCS not in Reset	N/A
ETHERNET 2	RX/TX	N/A	Ethernet Interface is not sending/receiving data	Ethernet Interface is sending/receiving data
	LINK	Physical connection to network established	Ethernet Interface is not sending/receiving data	N/A
ETHERNET 1	RX/TX	N/A	Ethernet Interface is not sending/receiving data	Ethernet Interface is sending/receiving data
	LINK	Physical connection to network established	Ethernet Interface is not sending/receiving data	N/A
ON-LINE	ON-LINE	TCS is on-line	TCS is off-line	N/A
HEALTH	SELF	Unit is functioning correctly	Unit is off-line or not functioning	N/A
	PARTNER	The partner unit (for AF-902) is functioning correctly	THE partner unit (for AF-902) is not functioning	N/A
U-LOK COMM	U-LOCK COMM	Communication established to Microlok II	Communication not established to Microlok II	N/A
BLK SPEED	LOCAL	Block Speed Set is Local	Local Block Speed is not set	N/A
	REMOTE	Block Speed Set is Remote	Remote Block Speed is not set	N/A
TRK CLEAR	LEVEL	Track is Clear	Track is occupied	N/A
	DATA	Track is Clear	Track is occupied	N/A

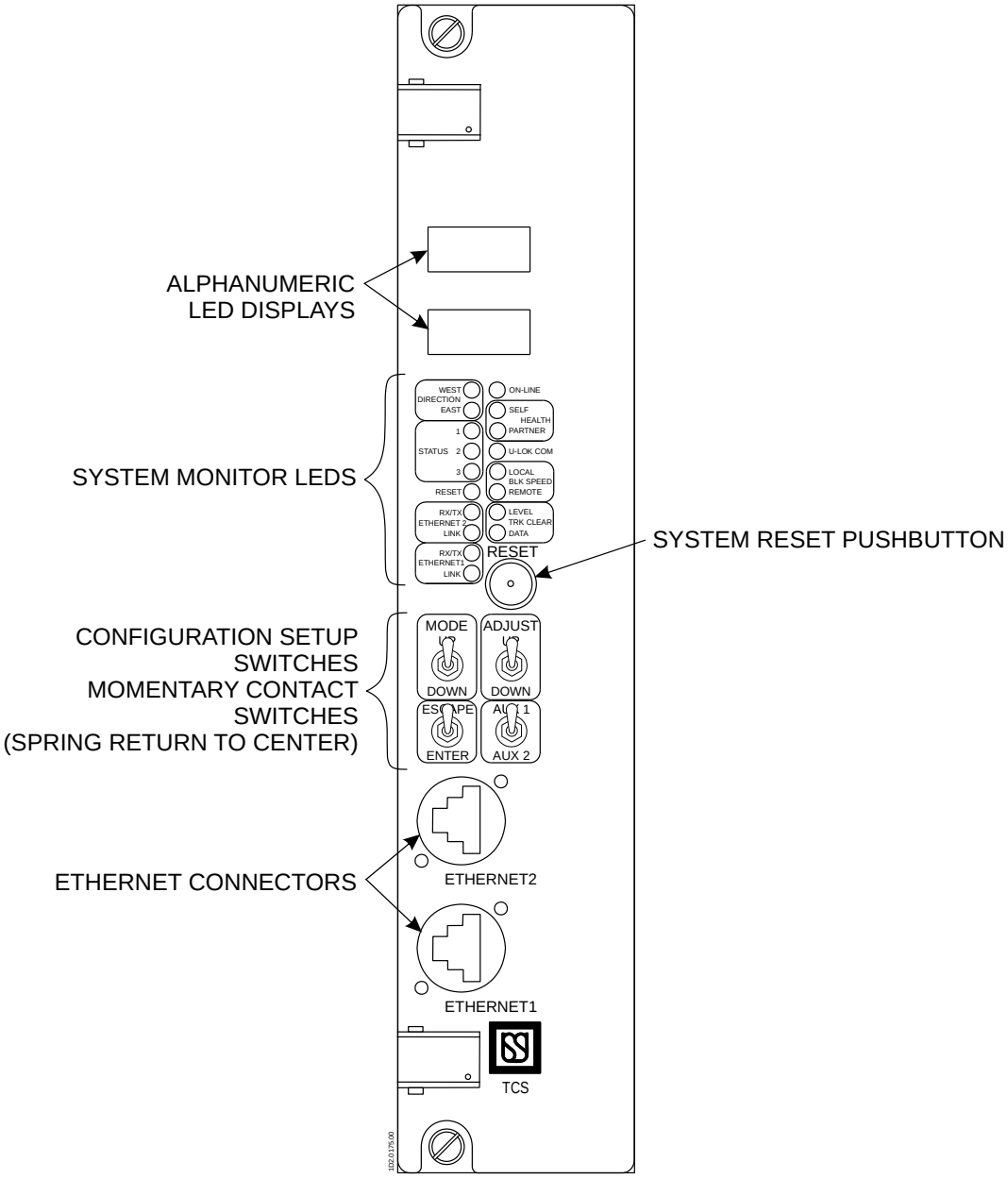


Figure 4-1. AF-902/AF-904 TCS Front Panel

4.2.2. Controls

The AF-902/904 system has four up-down SPDT toggle switches used to enter and examine data used in the setup and operation of the track circuit. Each menu of the AF-902/904 system uses the control switches for the following purposes:

Mode Up	Scrolls forward through selections or display parameters.
Mode Down	Scrolls backward through selections or display parameters.

Adjust Up	Increases the current parameter. Where appropriate, when the maximum value is reached, the parameter rolls over to the minimum value. In the Display submenus, the Adjust Up switch is used to modify the display code.
Adjust Down	Decreases the current parameter. Where appropriate, when the minimum value is reached, the parameter rolls over to the maximum value. In the display submenus, the Adjust Down switch is used to modify the display code.
Enter	Enters a submenu or confirms a parameter value.
Escape	Backs out of a submenu or cancels an operation.
Aux. 1	Enters the block speed menu. This switch has no effect on the restricted access menus.
Aux. 2	Enters the block speed menu. This switch has no effect on the restricted access menus.

The menus system Hierarchy is shown in Figure 4-2. The values shown in Figure 4-2 are examples. The actual values may or may not be the same as those shown in Figure 4-2.

4.2.3. Restricted Access Menus

Remove power to the partner AF-902 TCS before entering the setup mode. Erroneous entry of restricted access parameters may cause the system to behave in an unsafe manner. It is therefore necessary that these parameters be configured only by qualified personnel. Restricted access parameters can be modified only after a password is entered. Modified parameters can be made operational only after all changes are confirmed. When an operator enters the configuration submenu, the On-Line TCS will suspend normal operations and declare the track to be occupied. The TCS suspends track transmission and MICROLOK II response, and all outputs are put into a safe state. Normal operation resumes only after the system exits setup.

When a restricted access parameter is changed, it must be changed to the same value in both the Primary and Backup units in an AF-902 system. The only exception is the Block Speed setting. This value is communicated from the On-Line to the Backup unit. If the Primary and Backup have different values at startup, the most restrictive (lowest) speed will be used by both units. Since the AF-904 does not have a Backup unit, this function does not apply.

4.2.4. Main Menu

This menu is used to select a top level submenu function. The following top-level submenus are available from the Main menu: Block Speed, Display, Events, and Configuration. These submenu functions are described in the following sections. Since the Main menu is at the top of the hierarchy, the Escape front-panel control switch position has no effect from this menu.

4.2.5. Block Speed Menu

This menu is used to select the Block Speed Adjust submenu from which it is possible to set or modify a block speed. This menu option can also be entered immediately from any unrestricted access menu by toggling the Aux 1 or Aux 2 switch.

The Block Speed Adjust submenu is used to set a block speed. The Adj Up/Adj Dn switch modifies the current value (the value displayed on the lower display), and the Enter switch is used to enter the value. The operator must then confirm the value by toggling the Enter switch again, or reject the value by toggling the Escape switch to exit.

4.2.6. Display Menu

This option contains submenus that are used to display current system information. The following submenus are available from the Display menu: MICROLOK II Message, Track Message, and System Parameters. The Escape switch will move out of any Display submenu.

4.2.6.1. Microlok II Message

This menu contains submenus that are used to display the current message to MICROLOK II from the AF-902/904 system and the current message from MICROLOK II to the AF-902/904 system.

4.2.6.2. Track Message

This menu contains submenus that are used to display the following information:

- Current message being delivered to the track by the AF-902/904 system (Transmit menu).
- Level of the received signal as a percent of the threshold (Receive menu, Signal Strength (STR) submenu).

4.2.6.3. System Parameters

This menu is used to display the current system configuration. The following parameters are displayed: block speed, MICROLOK II address, track ID, Primary/ Backup, frequency, calibrated transmit power West, and calibrated transmit power East.

4.2.7. Events Menu

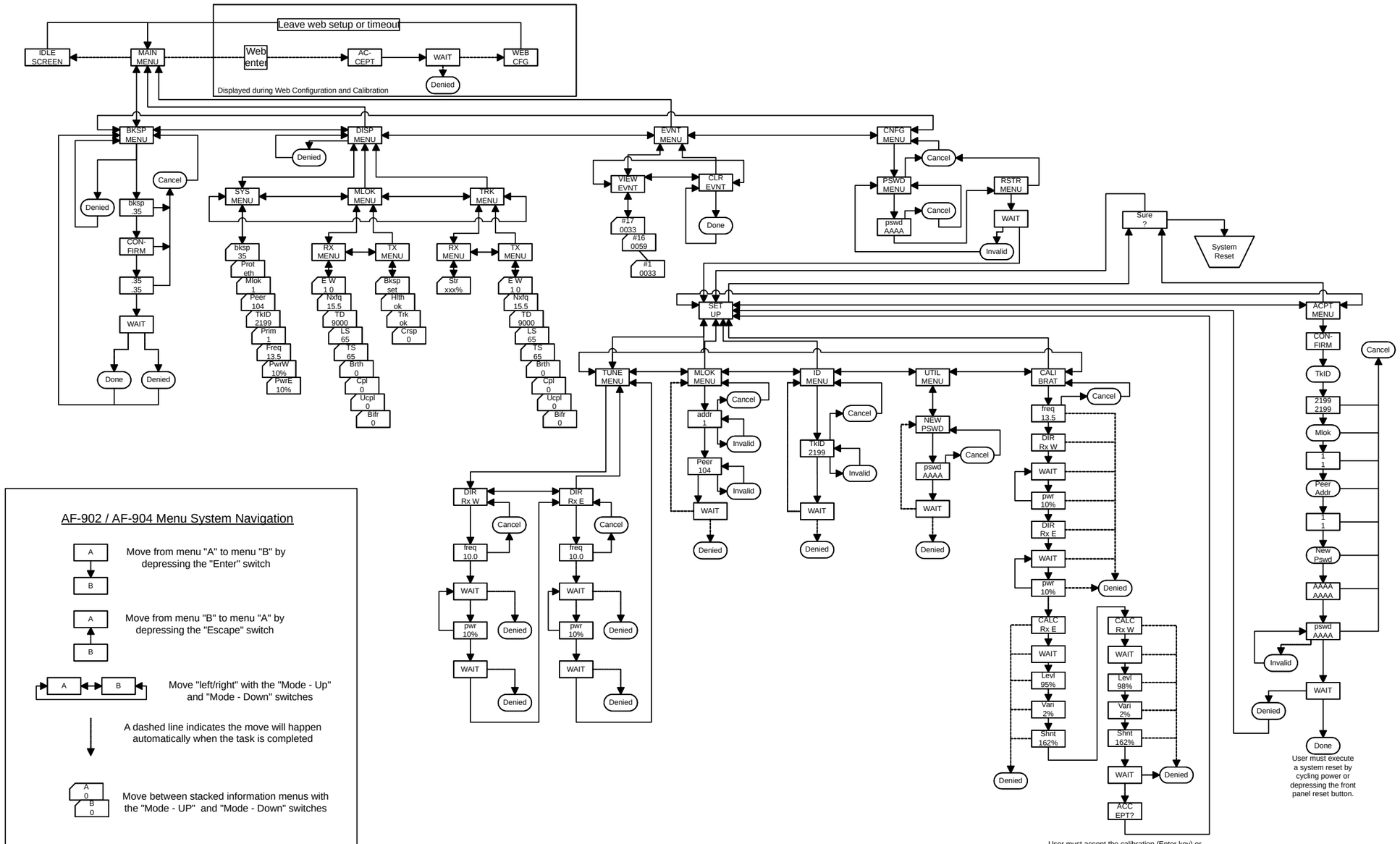
This menu is used to select a submenu from which it is possible to display events and manage the event logging system. The following submenus are available from the Events menu: View Events, and Clear Events.

4.2.7.1. View Events Menu

The View Events menu allows the user to view the event numbers (logged by the AF-902/AF-904 system) in the most-recent-first order.

4.2.7.2. Clear Events Menu

The Clear Events menu will erase all recorded event numbers from the AF-902/AF-904 memory.



AF-902 / AF-904 Menu System Navigation

A → B — Move from menu "A" to menu "B" by depressing the "Enter" switch

A ← B — Move from menu "B" to menu "A" by depressing the "Escape" switch

A ↔ B — Move "left/right" with the "Mode - Up" and "Mode - Down" switches

A dashed line indicates the move will happen automatically when the task is completed

A 0 / B 0 — Move between stacked information menus with the "Mode - UP" and "Mode - Down" switches

Note: When a menu allows a value to be adjusted, press the "ADJ - Up" to increase the value and "ADJ - Down" to decrease the value.

1102.0180.02

Figure 4-2. Menu System Hierarchy

4.2.8. Configuration Menu

This menu contains submenus that modify system parameters. The Password Entry submenu allows the user to enter the password. The Restricted submenu option contains other submenus that allow the user to modify critical system data.

4.2.8.1. Password Entry

This submenu option is used to enter and validate the restricted access password. The 4-character password is entered one character at a time. The active character flashes, while inactive characters are displayed constantly. Initially, "AAAA" is displayed and the leftmost character is active. The Adj Up/Adj Dn switches are used to advance the active character through the elements of the password character set. The Enter switch selects the current value of the active character and activates the next character.

The Password is stored in the EEPROM for each TCS. If the TCS requires replacement, the password is retained for the cardfile slot position.

The initial AF-902/904 password is four underscore characters, "_ _ _ _". The password can be changed through the front panel or using the Ethernet web server interface.

4.2.8.2. Restricted Menu Option

This submenu option is used to select a restricted access submenu. If the proper password has not been entered using the Password Entry menu, the submenus of the Restricted menu are not available. If there is a Backup unit in an AF-902 system it must be turned off prior to entering the Restricted menu. The following sections describe the submenus available from the Restricted menu. Exiting from the Restricted menu will cause the unit to reset.

After entering the Restricted menu, two menu selections are available: Setup and Accept.

4.2.8.3. Setup Menu

Selecting this menu, by toggling the Enter switch, will make five submenu selections available to the Maintainer: Tune, MICROLOK II, ID, Utility, and Calibration.

4.2.8.3.1. Tune Menu

The Tune submenu is used to configure the AF-902/904 system for train detection and cab signaling. The Tune menu contains several sequential submenus to be used in conjunction with the track circuit setup and tuning procedure. Because of the sequential nature of the tuning procedure, a menu item may have both a function and a submenu.

By using the Frequency Adjust menus, the user can change the carrier frequency in either the West to East or East to West signal transmission direction. The Adj Up/Adj Dn switches are used to modify the value that is displayed, and the Enter switch moves to the Power Output menu.

The Power Output menus provide an adjustment of transmitter power. The Adj Up/Adj Dn switches are used to modify the value that is displayed, and the Enter switch moves to the submenu.

4.2.8.3.2. Microlok II Menu

This menu permits the user to select the MICROLOK II Address Adjust submenu, which can be used to change the MICROLOK II station address.

4.2.8.3.3. ID Menu

With the ID menu option, the user can enter the track identification number (1 to 4095).

4.2.8.3.4. Utility Menu

This menu can be used to access New Password.

The New Password function allows the user to change the default password. The password is modified using the Adj Up/Adj Down switches and toggling the Enter switch sequentially confirms each character. The Escape switch backs up by one character or cancels the operation if the first character is displayed. After the password has been entered, the user is asked to confirm the value. A password that is modified and then confirmed immediately becomes the system password. The default password can only be restored by physically replacing the EEPROM on the motherboard.

4.2.8.3.5. Calibration Menu

Via the Calibration menu, the user sets the operating parameters of the AF-902/AF-904 system. The function and use of each submenu is described in Section 6.5.2 of this manual.

4.2.8.4. Accept Menu

This menu is used to confirm the changes that have been made to the restricted access system parameters. The Accept menu is a group of menus that sequentially prompt the maintainer to confirm the modifications that have been made to the system parameters. The parameter identifier is displayed first, followed by the new value shown on both the top and bottom displays.

The operator must toggle the Enter switch to confirm that both displays indicate the correct parameter or the Escape switch to abort the modification. After each modified parameter has been confirmed, a Password Entry menu is activated. This menu is similar to the menu described above. If the correct password is entered, the system parameters are written to the system EEPROM and will be used for all subsequent operations.

5. SERIAL AND NETWORK COMMUNICATIONS

The communications between the AF-902/904 and the MICROLOK II can be configured in many ways. If the MICROLOK Serial Protocol is used, the front panel Ethernet ports can be wired to a network to facilitate system setup and monitoring. This section provides several examples for system communications wiring.

NOTE

All network equipment switches must be rated for 100BaseT operation

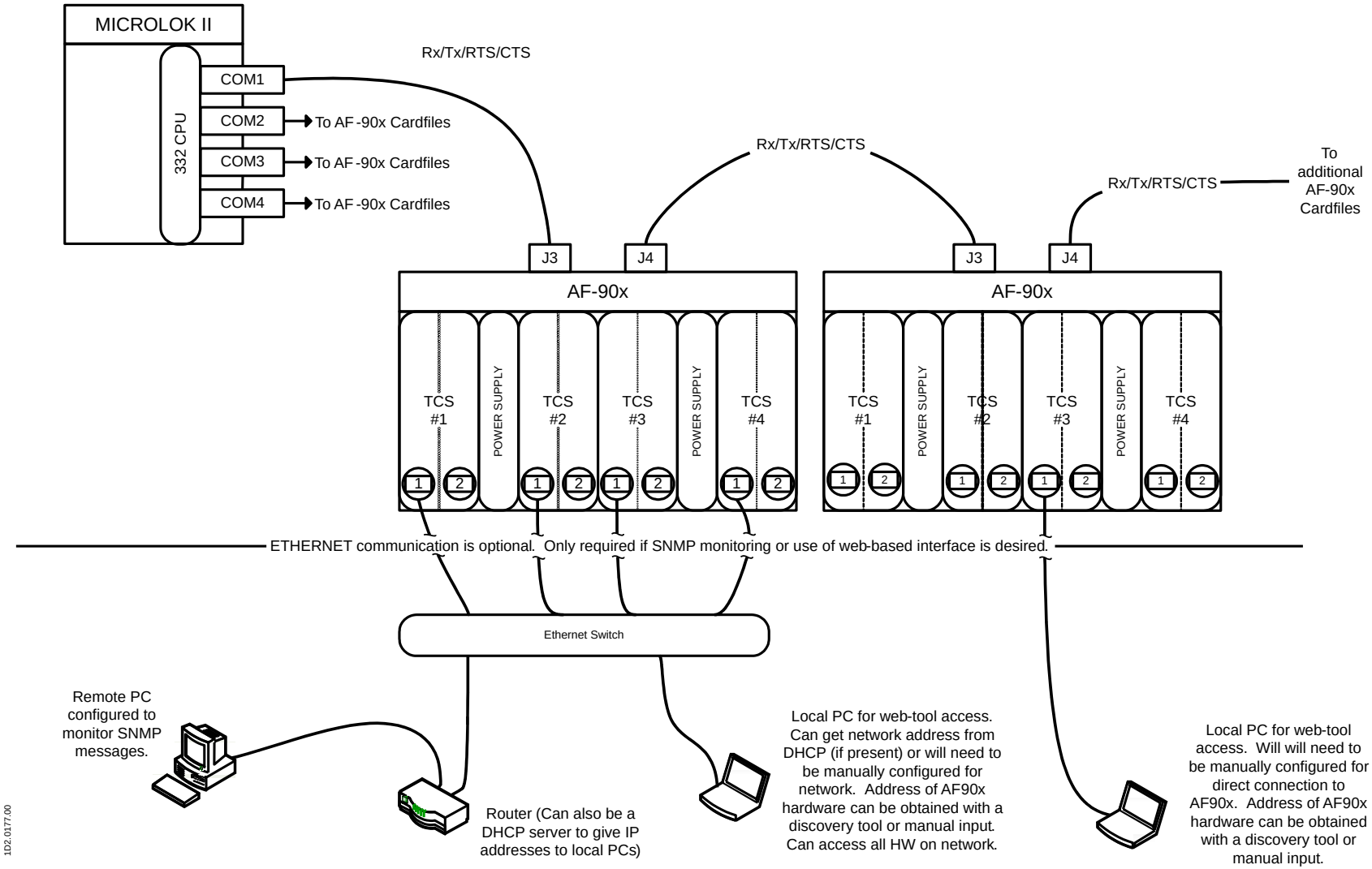

MICROLOK II
332 CPU
COM1
COM2
COM3
COM4
To AF-90x Cardfiles
To AF-90x Cardfiles
To AF-90x Cardfiles
Rx/Tx/RTS/CTS
Rx/Tx/RTS/CTS
Rx/Tx/RTS/CTS
To additional AF-90x Cardfiles
J3
J4
J3
J4
AF-90x
AF-90x
TCS #1
POWER SUPPLY
TCS #2
TCS #3
POWER SUPPLY
TCS #4
ETHERNET communication is optional. Only required if SNMP monitoring or use of web-based interface is desired.
Ethernet Switch
Remote PC configured to monitor SNMP messages.
Router (Can also be a DHCP server to give IP addresses to local PCs)
Local PC for web-tool access. Can get network address from DHCP (if present) or will need to be manually configured for network. Address of AF90x hardware can be obtained with a discovery tool or manual input. Can access all HW on network.
Local PC for web-tool access. Will will need to be manually configured for direct connection to AF90x. Address of AF90x hardware can be obtained with a discovery tool or manual input.
1D2.0177.00

Figure 5-1. RS-485 Communications

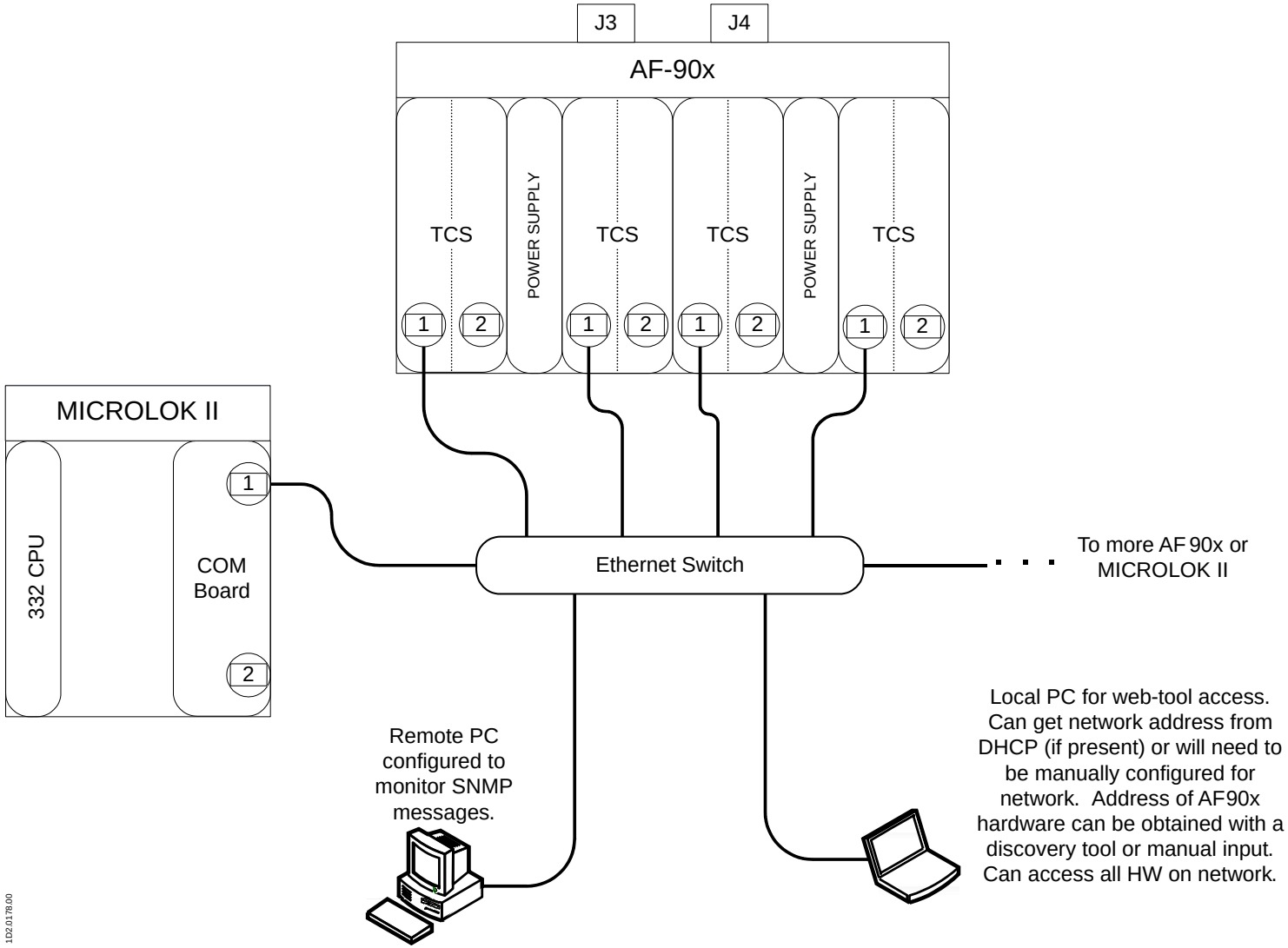

J3
J4
AF-90x
TCS
POWER SUPPLY
TCS
TCS
POWER SUPPLY
TCS
1
2
MICROLOK II
332 CPU
COM Board
Ethernet Switch
To more AF 90x or MICROLOK II
Remote PC configured to monitor SNMP messages.
Local PC for web-tool access. Can get network address from DHCP (if present) or will need to be manually configured for network. Address of AF90x hardware can be obtained with a discovery tool or manual input. Can access all HW on network.
1D2.017B.00

Figure 5-2. Non-Redundant Peer Communications

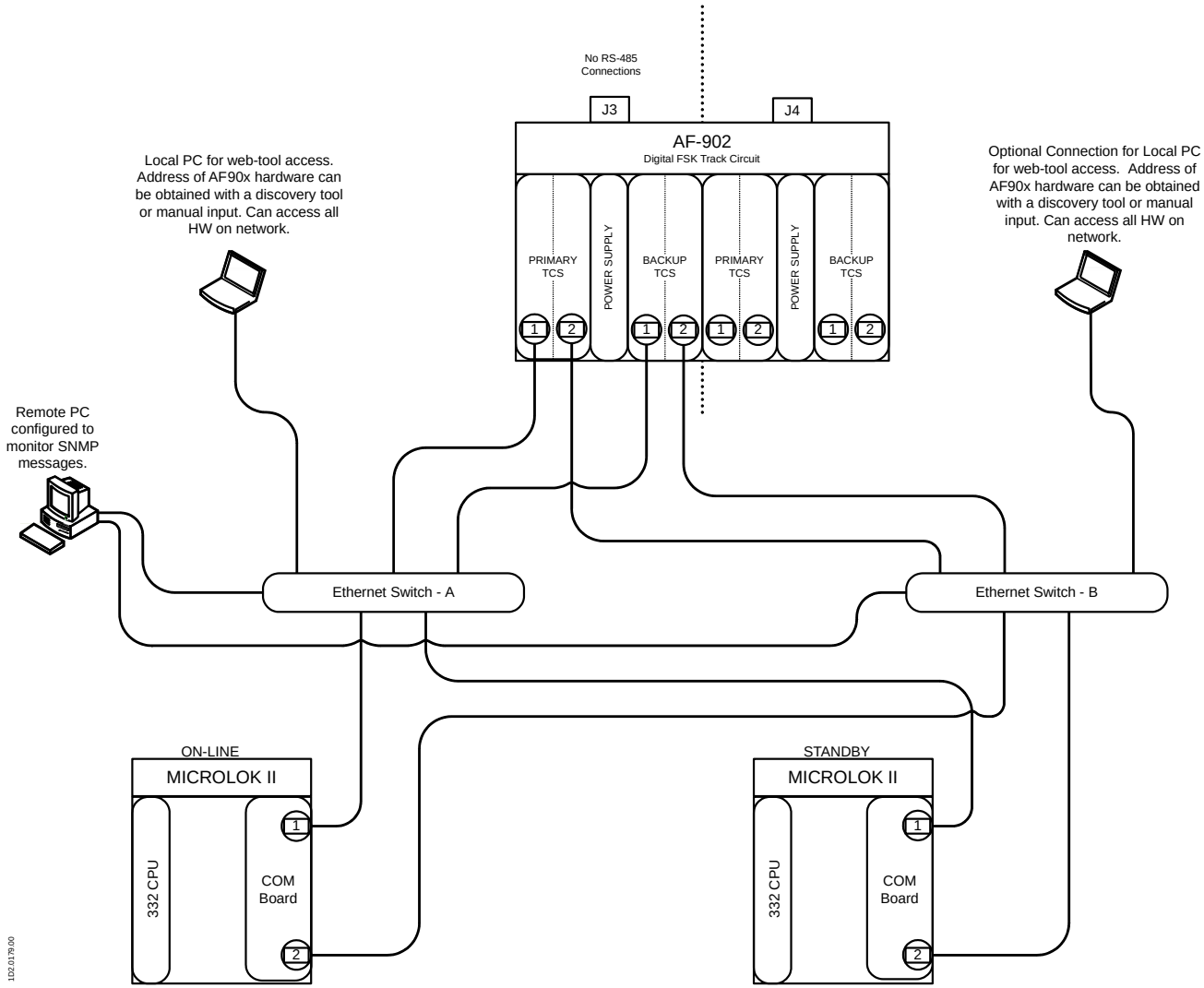


Figure 5-3. Fully Redundant Peer Network Communications

6. INSTALLATION AND ADJUSTMENT

6.1. Introduction

Track circuit installation and adjustment depend on the assigned track circuit frequency and track coupling methods.

Installation procedures should be in accordance with those recommended by the equipment manufacturers for any equipment that interfaces to the AF-902/904 unit.

Refer to the specific site plans for detailed installation and track coupling requirements, such as track circuit lengths, frequency assignments, track circuit identifications, and wiring sheets.

6.2. Recommended Test Equipment

The following equipment is recommended for testing the AF-902/904 unit:

- Spectrum Analyzer: Tektronix TDS 3012B or C Oscilloscope or Hewlett-Packard HP3560A Dynamic Signal Analyzer. (Refer to Section 11 for Tektronix TDS 3012B setup instructions.)
- Current Probe: Tektronix A621 AC Current Probe or Fluke 80i 1000s Current Transformer.
- AAR Style 1/2 in. hex socket wrench used for loosening and tightening AAR standard terminal posts.
- Red tags for identifying failed system components.
- Two VOLTREX 855-B Insulated Tip Plugs for Front Panel test probes.
- Hand-held radios with 2-mile (3.2 km) range minimum.
- Track Shunt 0.25 ohms total resistance. The track shunt resistor itself is 0.20 ohms and the leads to the rails are 0.05 ohms.

6.3. Serial Link Termination

A MICROLOK II can communicate to multiple AF-902/904 units through a multi-drop RS-485 link. Terminating resistors must be connected at the physical end of the link, i.e., at the AF unit farthest from the MICROLOK II. Connecting the terminating resistors at the end unit is accomplished by closing the four SW1 DIP switches on the back of the AF motherboard (See Figure 6-4). Otherwise, the four SW1 DIP switches should remain open.

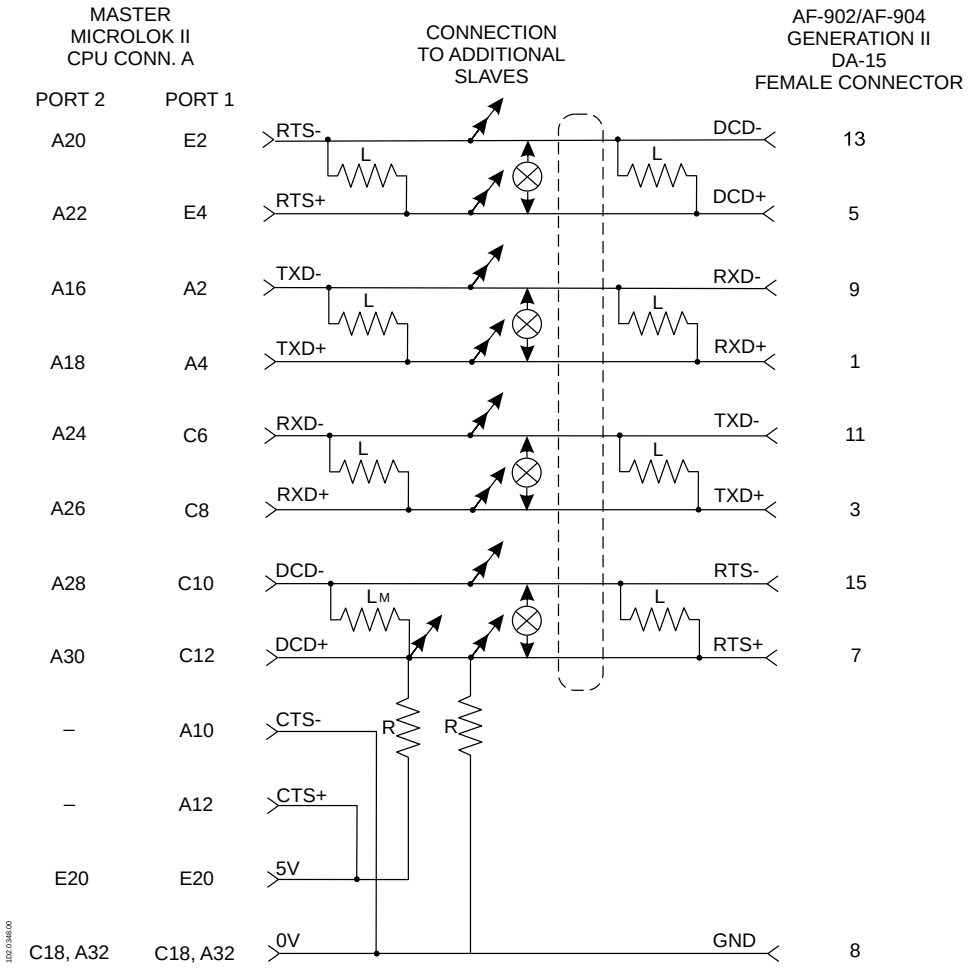


Figure 6-1. Typical Microlok II Master To AF-902/AF-904 Generation II Units Powered By Same Battery (Microlok Protocol Or Half-Duplex Genisys Protocol)

1. Resistors (R) are 470 Ohm, ½ watt.
2. For full duplex Genisys Protocol RTS and DCD need not be connected.
3. Serial commons are interconnected through a battery that powers Microlok II units.
4. Load resistors (L) are provided by DIP Switch SW1 on the rear of the AF-902/AF-904 Generation II cardfile. The individual switches of SW1 must all be in the OPEN or CLOSED position. The resistors are connected into the circuit when the switches are in the closed position.
5. Load resistor (Lm) is 240 Ohm, ½ watt and is installed on master DCD only, as shown.
6. Do not connect COMMUNICATION COMMON to ground.

6.4. Vital Parallel Output Terminations

A provision for terminating an unused vital parallel output is available (See Figure 2-7 and Figure 2-8). When the VPO is unused, place the jumper for that track circuit in position 2-3 to terminate the output.

6.5. System Setup Procedure Using the Network Interface

The AF-902/904 system's TCS includes a built in web server user interface. The web-server interface can be used instead of using the front panel toggle switch interface. A PC using Internet Explorer web browser version 6.0 or later can be connected to the internal server through the front panel or the Ethernet port. Connection can be a direct cable connection or through a network switch. An Ethernet switch can be used to access any one of an installation's AF-902/904 from a single location.

The Setup tab on the AF-902/904 web page is the entry point to the calibration and configuration features of the system. Entry is password protected and also requires the user to be close to the AF-902/904 TCS. After the password is correctly entered, the user is required to toggle the Enter switch on the front panel. This confirms that the user is working with the correct AF-902/904 and that calibration or configuration is not being attempted from a remote location.

Be aware that most web browsers, like Internet Explorer will cache web pages. This can possibly lead to the display of old data. When interfacing to the AF-902/904, caching should be disabled. This is typically done in Internet Explorer by selecting Tools – General – Temporary Internet files, Settings – under "Check for new version of stored pages", select "Every visit to the page".

6.5.1. Configuration

This manual will use the term "configuration" to refer to the setting of all system operational parameters except those associated with the frequency and power level of the track signal. Configuration is typically performed only once, when the AF-902/904 system is initially installed. Since the parameter values are stored in the cardfile EEPROM, the set parameter values will be still be in effect if the TCS is replaced.

6.5.1.1. Setting the AF-902/904 to the Default IP Address

When configuring a new system or if the IP addresses of a system have been lost, the default IP addresses for the front panel Ethernet ports can be set by placing the #1 switch of switch bank SW1 to the ON position and resetting the AF-902/904 system. SW1 is located near the front of the CPU, daughter board on the TCS. The TCS power must be turned off before removing the TCS from the cardfile to set the default IP address switch, SW1. The final switch position for normal operation will be: SW1 switches #1 and 32 OFF, SW2 switch #2 OFF, and all other SW1 and SW2 switches in either the ON or Off positions.

The default IP address for ETHERNET1 is 169.254.1.10, and ETHERNET2 is 169.254.2.20. If the IP addresses for your Ethernet ports are known, this step can be skipped.

6.5.1.2. Setting The PC's Network IP Address

To connect to a TCS using the default address, set the PC's TCP/IP network address to 169.254.1.11 with a subnet mask of 255.255.255.0 and directly connect to ETHERNET1 port on the AF-902/904. (Or you can set your PC's TCP/IP network address to 169.254.2.21 with a subnet mask of 255.255.255.0 and directly connect to ETHERNET2 port on the AF-902/904.) To use a non-default address, set the PC to an unused subnet address.

The direct-connection Ethernet cable (CAT-5) may be a standard "straight-through" cable or a "cross-over" cable.

Proceed as follows to set a Windows PC's TCP/IP address:

7. Click Start – Settings or Control Panel – Network Connections
8. In the window that opens, right click on your network connection and select Properties.
9. In the window that opens, scroll down to Internet Protocol (TCP/IP) and select Properties.
10. Select "Use the following IP address" and type in the desired IP address and Subnet mask. Use 169.254.1.11 (255.255.255.0) or 169.254.2.11 (255.255.255.0) or an unassigned subnet address and gateway for non-default use.
11. Select OK buttons to close all windows. There will be a several second delay while Windows is changing your Ethernet port's address.

6.5.1.3. Connecting to the AF-902/904

After the AF-902/904 IP address is known or set to the default and the PC is configured to the same subnet, the PC can connect to the AF-902/904 system's internal web server. Open Internet Explorer and type in the IP address of the AF-902/904 Ethernet port on the Address line. This will be default address or your network's designated address. Internet Explorer should show the View Current Data page for the AF-902/904.

6.5.1.4. Entering Setup

Selected the "Setup" tab and wait for the Password drop-down window to appear. Enter your 4-character password. If you have not previously set a new password, the default is 4 underscores (_ _ _ _). If the correct password has been entered, you will be prompted to toggle the "Enter" switch on the front of the AF-902/904 TCS. This is the lower left toggle switch. When this is completed the drop down box will rise and you will be in the Setup Mode.

6.5.1.5. Setting the Configuration Parameters

In the Setup Mode you will have a new set of tabs to select the parameters that you will be adjusting. Please be careful, if you select one of the original tabs, View Current Data, View Configuration, etc., you will immediately exit Setup Mode and all changes will be lost.

When setting up a new system, the first tab you should select is the Configuration tab. On this page you will be setting up the AF-902/904's Ethernet port's addresses and the addresses of the connection MICROLOK II's if Peer Protocol communications is in use. Figure 6-2, Table 6-1, Table 6-2, and Table 6-3 are examples of the Setup page and data that is to be entered.

After all parameters have been set, you must click on the "Commit" button to transfer the data to the AF-902/904. You must exit the Setup Mode using the Exit tab before the values will be retained by the AF-902/904 in its cardfile EEPROM.

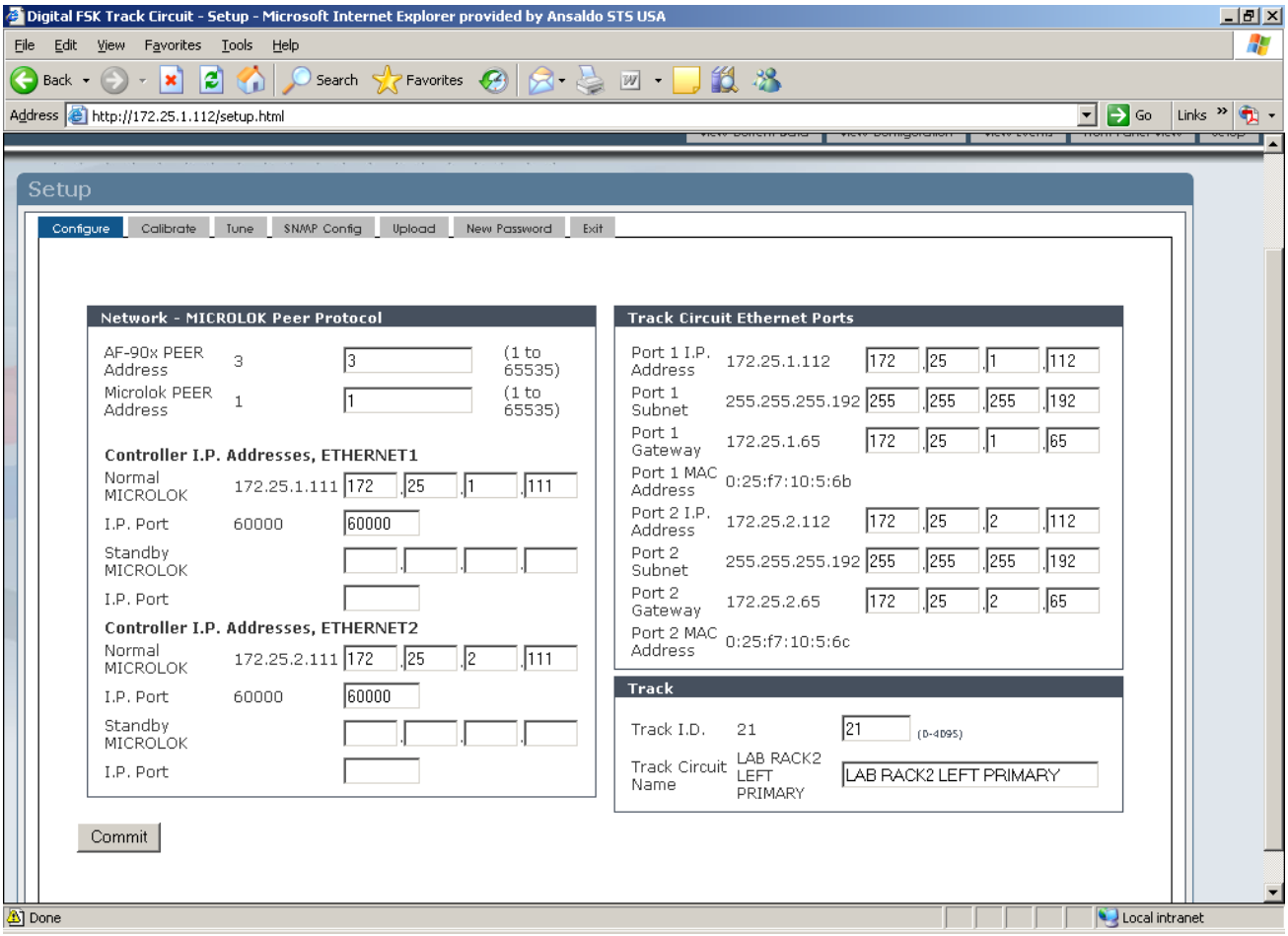

Digital FSK Track Circuit - Setup - Microsoft Internet Explorer provided by Ansaldo STS USA
File Edit View Favorites Tools Help
Back Search Favorites
Address http://172.25.1.112/setup.html
Go Links
Setup
Configure Calibrate Tune SNMP Config Upload New Password Exit
Network - MICROLOK Peer Protocol
AF-90x PEER Address 3 3 (1 to 65535)
Microlok PEER Address 1 1 (1 to 65535)
Controller I.P. Addresses, ETHERNET1
Normal MICROLOK 172.25.1.111 172 25 1 111
I.P. Port 60000 60000
Standby MICROLOK
I.P. Port
Controller I.P. Addresses, ETHERNET2
Normal MICROLOK 172.25.2.111 172 25 2 111
I.P. Port 60000 60000
Standby MICROLOK
I.P. Port
Track Circuit Ethernet Ports
Port 1 I.P. Address 172.25.1.112 172 25 1 112
Port 1 Subnet 255.255.255.192 255 255 255 192
Port 1 Gateway 172.25.1.65 172 25 1 65
Port 1 MAC Address 0:25:f7:10:5:6b
Port 2 I.P. Address 172.25.2.112 172 25 2 112
Port 2 Subnet 255.255.255.192 255 255 255 192
Port 2 Gateway 172.25.2.65 172 25 2 65
Port 2 MAC Address 0:25:f7:10:5:6c
Track
Track I.D. 21 21 (0-4095)
Track Circuit Name LAB RACK2 LEFT PRIMARY LAB RACK2 LEFT PRIMARY
Commit
Done
Local intranet

Figure 6-2. Setup Page

The Network – MICROLOK Peer Protocol table is replaced with a smaller table when the RS-485 MICROLOK Serial protocol is used. This table only requires you to enter the AF902/904's slave address.

Table 6-1. Network – Microlok Peer Protocol

Network – MICROLOK II	
AF-90x PEER Address	The AF-902/904's Peer Protocol Address.
MICROLOK II PEER Address	The MICROLOK's Peer Protocol Address.
Controller I.P. Addresses, Ethernet1	
Normal MICROLOK II	The IP address of the MICROLOK II that is connected to the AF-902/904's ETHERNET1 port.
I.P. Port	This is the MICROLOK II's internal port address; it should be set to 60000 unless the MICROLOK II's application program has defined a different port number.
Standby MICROLOK II	The IP address of a second, standby MICROLOK II connected to the AF-902/904's ETHERNET1 port. (If used)
I.P. Port	This is the MICROLOK II's internal port address; it should be set to 60000 unless the MICROLOK II's application program has defined a different port number. (If used)
Controller I.P. Addresses, Ethernet2	
Normal MICROLOK II	The IP address of the MICROLOK II that is connected to the AF-902/904's ETHERNET2 port. (If used)
I.P. Port	This is the MICROLOK II's internal port address; it should be set to 60000 unless the MICROLOK II's application program has defined a different port number. (If used)
Standby MICROLOK II	The IP address of a second, standby MICROLOK II connected to the AF-902/904's ETHERNET2 port. (If used)
I.P. Port	This is the MICROLOK II's internal port address; it should be set to 60000 unless the MICROLOK II's application program has defined a different port number. (If used)

The Track Circuit Ethernet Ports information must be provided by your systems network designers.

Table 6-2. Track Circuit Ethernet Ports

Track Circuit Ethernet Ports	
Port 1 I.P. Address	The AF-902/904's ETHERNET1 port's IP address.
Port 1 Subnet	The subnet mask for ETHERNET1 port.
Port 1 Gateway	The gateway address for ETHERNET1 port.
Port 1 MAC Address	The hardware address for ETHERNET1, this is not changeable.
Port 2 I.P. Address	The AF-902/904's ETHERNET2 port's IP address.
Port 2 Subnet	The subnet mask for ETHERNET2 port.
Port 2 Gateway	The gateway address for ETHERNET2 port.
Port 2 MAC Address	The hardware address for ETHERNET2, this is not changeable.

Table 6-3. Track

Track	
Track I.D.	The Track I.D. number that will be included in the Track Message. This number must be assigned by the system designer.
Track Circuit Name	This is text message displayed on the top of the web pages to help the maintainer identify the specific track circuit.

After setting the configuration values, select the "Commit" button. A yellow banner will briefly appear above the tables, confirming that the values have been sent from your PC to the AF-902/904 for temporary storage. At this time you can set the SNMP parameters (provided by your network designer) and set a new password if desired. These functions have tabbed pages in the Setup Mode display.

Upon completion of Configuration, you must exit the Setup Mode by selecting the Exit tab. You will be presented with a page of all parameter values for review. If the all values are correct, select the confirmation button and re-enter the system's password. This must be the same password used to enter the Setup Mode. You will be prompted to reset the AF-902/904. This can be done using the front panel reset button or cycling power to the AF-902/904. If you are going to use the user-selected AF-902/904 IP settings, the default IP address switch (SW1-1) (Figure 6-3) must be placed in the OFF position. The TCS must be removed from the cardfile to access switch SW1. Remove power from the TCS before removing the TCS from the cardfile. When power is turned back on to the TCS, it will use the IP network parameters that have been set. Change your PC's address as described in Section 6.5.1.2 to operate in the same subnet as the AF-902/904.

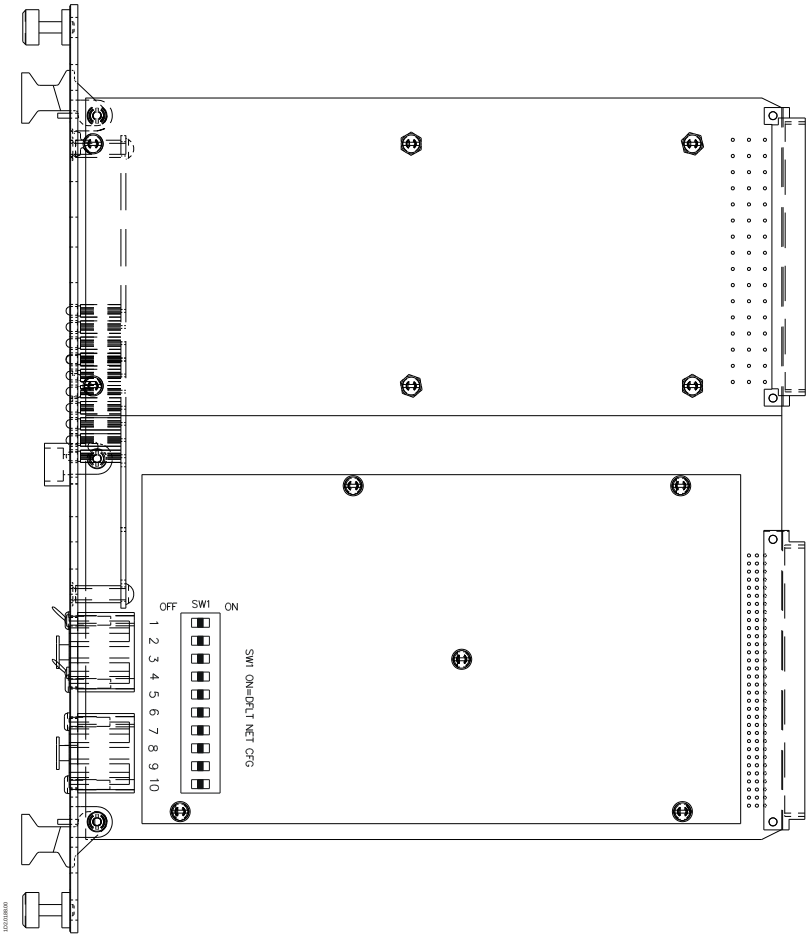


Figure 6-3. TCS Daughterboard Switch SW1 Location

6.5.2. Calibration

This section provides an overview to using the web page interface to calibrate an AF-902/904. The web page interface provides an alternative to using the front panel interface to calibrate an AF-902/904. The calibration procedure is the same for both interfaces. A detailed calibration procedure is provided in Section 6.6.

NOTE

Before entering the setup mode to make any tuning or calibration adjustments, you must turn off the power to an AF-902 partner TCS and to both adjacent track circuit AF-902/904 systems.

Calibration of an AF-902/904 system involves three main steps as follows:

1. Tuning the bond for the maximum transfer of power to and from the track.
2. Setting the AF-902/904 transmission power to set the rail current to a level that assures that a train reliably receives the track signal data.
3. Setting the AF-902/904 receiver signal to a level that provides reliable train occupancy and broken rail detection.

6.5.2.1. Tuning

Tuning adjusts the impedance of the bond to provide maximum transfer of the track signal to the rail. It is typically performed at 400 Hz below the specified track carrier frequency: 9.5 kHz to 16.5 kHz. This will result in a low variance in the amplitude of the space and mark frequencies. Both coupling units must be tuned, each when they are the receiving end of the circuit. Tuning is typically only done during the initial installation of the track circuit. Retuning is usually only needed if a bond is replaced or a high variance value is noted during the setting of the rail current.

Prior to tuning a track circuit, place the TCS Tx jumper on the back of the AF-902/904 cardfile to the 3 position and the Rx jumper to the 2 position.

Enter the Setup Mode as describe in Section 6.5.1.4 and select the Tuning tab. The Tuning page provides the user with three controls; direction, frequency and power level. The frequency should be set to 400 Hz below the designed track circuit carrier frequency. After changing the controls, select the "Try" button to send the desired values to the AF-902/904 for transmission.

Specific steps and details of the tuning procedure are given in Table 6-7.

6.5.2.2. Setting the Rail Current

Setting the rail current assures that the train is able to receive a reliable track signal. The nominal value of I_{RAIL} for each carrier frequency is listed in Table 6-10 and Table 6-11. The rail current is set by adjusting the transmitter's power while measuring the bond current at the receiver end of the track circuit.

Prior to making any adjustment, verify that the Rx tap on the rear of the cardfile is in the Tap 2 position.

Because of the large dynamic range imposed by the needs of different track circuits, the AF-902/904 Control cardfile incorporates five adjustable transformer taps for TCS Transmitter circuits. These allow for variables such as different track lead lengths. Adjustments are made via jumpers on the cardfile backplane.

Output power is varied by two means:

Coarse:	Output Transformer Taps (1 through 5) on back of the AF-902/904 motherboard. Taps act to double output amplitude with each increased setting. (TXA= Primary; TXB = Backup)
Fine:	Pulse width, the "ON" duty cycle percentage of a Full Cycle.

The Receiver Tap will always be set to Tap 2 position.

The AF-902/904 web interface provides a guided calibration procedure in the Setup Mode, Calibration tab. You will be directed to set the specified track circuit frequency and then set the transmitter power level in both directions. Transmitter power is roughly adjusted by using Tx taps on the rear of the cardfile. The output power is double for each step of the Tx tap. Fine adjustment is performed by adjusting the signals pulse width using the on screen power levels, 25 to 95%. The right side of the Calibration page provides a table listing the calibration values from the last accepted calibration.

6.5.2.3. Setting the Receiver Level

The AF-902/904 system will automatically adjust the receiver level during the completion of the calibration sequence. The values of Variance, Gain, Rx Level, and Shunt Level are then calculated for each direction and displayed on the web page.

When the AF-902/904 system performs the calculations, it assigns the current received signal level to the 162% shunt level. Calibrations must always be performed at nominal track ballast conditions. If you recalibrate a system under extreme ballast conditions, the AF-902/904 will assign the 162% shunt level to an incorrect received signal level.

When the TCS is unable to calculate valid values for these parameters, it will display Variance, Gain and Rx Level = 0 and Shunt Level as '---'. This would indicate an incorrectly wired or adjusted track circuit, or it will be the normal and acceptable result of calibrating a Cab Loop track circuit. Cab Loop track circuits do not have a received signal and do not determine occupancy.

When the calibration is successful, the power levels and calculated values will be stored in the TCS's EEPROM on the cardfile.

6.6. Detailed Calibration Procedure

The first step in setting up a new or modified track circuit is to tune the track coupling units. Tuning matches the impedance of the AF-902/904 to the bond impedance, allowing maximum power transfer.

Tuning is done at the coupling units mounted near the track bond. The coupling unit contains two identical circuits, which are separated by a dashed line down the middle of the PCB. The operator should take care in determining which of these circuits is to be tuned before proceeding.

NOTE

The following procedures detail calibration using the front panel. Calibration can also be done through the web server interface. The same procedural steps are followed.

The two TCS units in an AF-902 system are distinguished by using standard text for the left unit circuit and {BRACKETS} for the {RIGHT UNIT} circuits.

Tuning affects both the transmitted and received signal levels, making it MANDATORY that the tuning procedure be performed first as part of the setup routine.

For preventive maintenance purposes, since the system is operational and tuning has been completed at some earlier date, calibration alone can be performed as the sensitivity check. However, if calibration is marginal, it may be necessary to perform both the tuning procedure and calibration procedures.

The detailed steps to tuning are provided in Table 6-7.

Calibration of the signal power must be performed after the tuning procedure since it is affected by the resulting tuning signal levels. Specific steps and details of the calibration procedure are given in Table 6-9.

6.6.1. Testing Codes and Abbreviations

6.6.1.1. Controller Board Front Panel Display Abbreviation Codes

Basic character and case assignments used for performing the test procedures are as follows:

[AAAA]	Upper Menu or Command
[Aaaa]	Label Parameter
[BKSP]	Block Speed
[MLOK]	MICROLOK II
[TUNE]	Tuning Procedure
[Levl]	Input Rec Level
[CALI] [BRAT]	Calibration Procedure
[Shnt]	Shunted with respect to Level
[MLOK]	MICROLOK II Address Set Menu
[aaaa]	Changeable Parameter
[ID]	Track Circuit ID Set Menu
[tkid]	Track Circuit ID Parameter
[PSWD]	Password
[pwr]	Output Pulsewidth
[RSTR]	Restricted Menu

6.6.2. Test Equipment and Tools

The equipment and tools required for the tuning and calibration procedures are listed below. The test engineer should select the appropriate tools for the required test procedure.

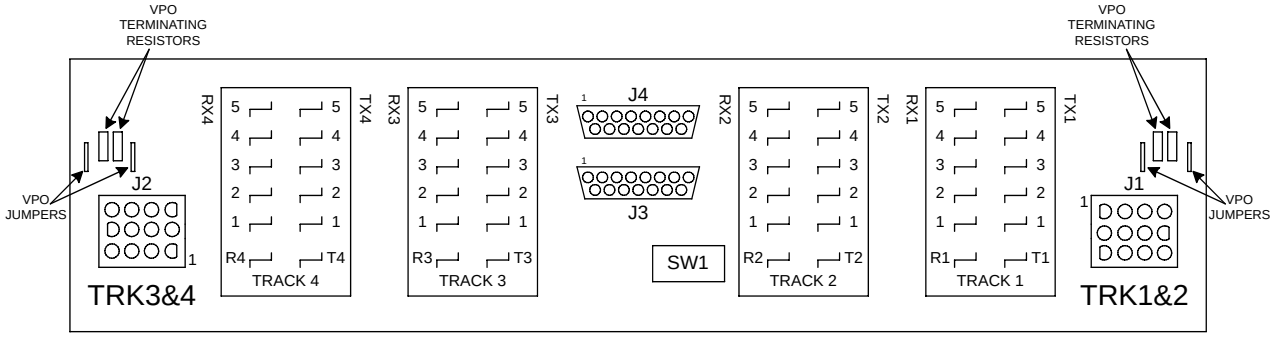
- Spectrum Analyzer: Tektronix TDS 3012B or C Oscilloscope or Hewlett-Packard HP3560A Dynamic Signal Analyzer. (See Section 11 for Tektronix TDS 3012B setup instructions.)
- Current Probe: Tektronix A621 AC Current Probe or Fluke 80i 1000s Current Transformer
- AAR Style 1/2 in. hex socket wrench used for loosening/tightening AAR standard terminal posts
- Red tags for identifying failed system components
- Two VOLTREX 855-B Insulated Tip Plugs for system component Front Panel test probes
- Handheld radios with 2-mile (3.2 km) range minimum
- Track Shunt 0.25 ohms total resistance. The track shunt resistor itself is 0.20 ohms and the leads to the rails are 0.05 ohms.

6.6.3. Transmit Power Adjustments

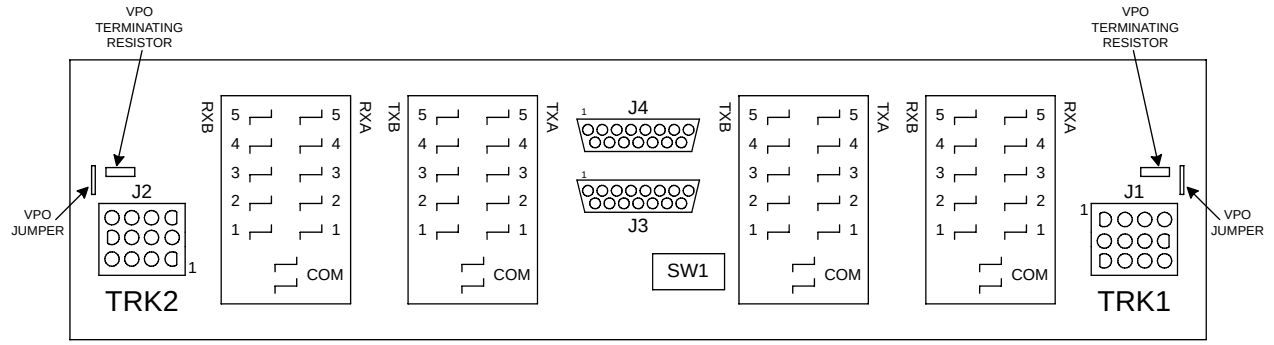
During the test procedure, it may become necessary to adjust the output power in order to meet specifications. Output power can be varied by two means:

Coarse: As Figure 6-4 shows, the Output Transformer Taps (1 through 5) on back of the AF-904/904 motherboard are selected by means of jumper wires connected between the numbered taps and Signal Common points (labeled COM for AF-902, and R1 through R4 and T1 through T4 for AF-902). Taps act to double the output amplitude with each increased setting (TXA=Primary; TXB=Backup).

Fine: Pulse width, the ON duty cycle percentage of Full Cycle in 5% increments from 25 to 95%. This is set from the front panel PWR submenu option. It is done during the calibration procedure, and can be done only after the operator has traversed the Configuration menu with the correct password. There is a separate pulse width setting for each direction of track circuit transmission. After these are SET and ACCEPTED, they are stored in EEPROM.



AF-904 Upper Cardfile Rear View



AF-902 Upper Cardfile Rear View

Figure 6-4. AF-902/904 Upper Cardfile Rear Views

6.6.4. Setup Overview

There are several parts to the setup procedure, as described in the following subsections.

6.6.4.1. 350 or 500 MCM Bond Setup Procedure

To setup the AF-902/904 system using a 350 or 500 MCM Bond in either an "S" or "O" or "I" configuration, follow the procedure given in Table 6-4, Table 6-5, Table 6-7, and Table 6-9, and use the Data Sheet (Figure 6-5) at the end of this section. Setting the MLOK address and the track circuit ID (Table 6-6) can be performed at any time in the sequence. Tuning (Table 6-7) must be performed before calibration.

6.6.4.2. Cab Loop Setup Procedure

Follow the procedure in Table 6-4 and Table 6-12, and use the data provided at the end of this section. Setting the MLOK address and track circuit ID (Table 6-6) can be performed at any time in the sequence. The AF-902/904 system performs track signal transmission only.

6.6.4.3. Direct Injection Track Circuit

For setting-up the AF-902/904 system using a direct injection track circuit, follow the procedure in Table 6-4, Table 6-6, and Table 6-13, and use the Data Sheet (Figure 6-6) at the end of this section. Tuning is not required for a direct injection circuit.

6.7. AF-902/904 Track Circuit System Setup and Test

NOTE

Before entering the setup mode to make any tuning or calibration adjustments, you must turn off the power to an AF-902 partner TCS and to both adjacent track circuit AF-902/904 systems.

Table 6-4. Entering AF-902/904 Front Panel Restricted Menu For Setup

FRONT PANEL RESTRICTED MENU ACCESS PROCEDURE
From **[MAIN][MENU]** toggle *ENTER*
Toggle *MODE* to **[CNFG][MENU]**
Toggle *ENTER* for **[PSWD][MENU]**
Toggle *ENTER* for **[pswd][AAAA]**
ADJUST characters and *ENTER*, the default is four underscores (_ _ _ _).
Unit enters **[RSTR][MENU]**
Toggle *ENTER*. If pswd is OK, unit goes into **[SET][UP]**

Table 6-5 provides the sequence of steps to enter the Setup mode by using the web server interface.

Table 6-5. Entering AF-902/904 Setup Using the Web Server Interface

SETUP MENU ACCESS PROCEDURE
SELECT the **SETUP** tab
ENTER the 4-character password, the default is four underscores (_ _ _ _)
Toggle the **ENTER** switch on the front of the AF-902/904 TCS
The drop down box will rise and you will be in the Setup Mode.

Table 6-6 provides the sequence of steps required to set the AF-902/904 system's communications address and Track ID using the front panel interface. Section 6.5 describes setting these parameters using the web page interface. If the system is using the RS-485 MICROLOK Serial Protocol then the AF-902/904 system's address is a number from 1 to 127. If the system is using the Ethernet MICROLOK Peer Protocol then the AF-902/904 system's address is a number from 1 to 65535. The Track ID number is a number between 0 and 4095 that is assigned by the system architects and should be obtained from the track plan.

Table 6-6. Setting the Communications Address and Track Circuit ID

STEP	SETTING THE COMMUNICATIONS ADDRESS	SETTING THE TRACK CIRCUIT ID NUMBER
1	Obtain track circuit MICROLOK Serial Protocol or Peer address from hardware drawings.	Obtain track circuit ID from Control Line drawings.
2	Traverse restricted menu as described in Table 6-4. [SET][UP] Toggle *ENTER* for [TUNE][MENU]	Traverse restricted menu as described in Table 6-4. [SET][UP] Toggle *ENTER* for [TUNE][MENU]
3	Toggle *MODE* to [MLOK][MENU] Toggle *ENTER* for [addr][xx] ADJUST addr (1-127) for Serial Protocol or ADJUST the Peer address (1 to 65535) Toggle *ENTER* for [MLOK][MENU] Toggle *ESCAPE* for [SET][UP] Toggle *MODE* to [AC-][CEPT]	Toggle *MODE* to [ID][MENU] Toggle *ENTER* for [tkid][xxxx] *ADJUST* tkid (0-4095) Toggle *ENTER* for [ID][MENU] Toggle *ESCAPE* for [SET][UP] Toggle *MODE* to [AC-][CEPT]
4	Toggle *ENTER* for [CON-][FIRM] Toggle *ENTER* to scroll through all parameter settings. * Accept by toggling *ENTER*. * Reject by toggling *ESCAPE*.	Toggle *ENTER* for [CON-][FIRM] Toggle *ENTER* to scroll through all parameter settings. * Accept by toggling *ENTER*. * Reject by toggling *ESCAPE*.
5	If all parameters are CONFIRMED, unit will write setup parameters to EEPROM and [DONE] Toggle *ENTER* for system reset. Record track circuit MLOK Addr on Track Circuit Data Sheet (Figure 6-5).	If all parameters are CONFIRMED, unit will write setup parameters to EEPROM and [DONE] Toggle *ENTER* for system reset. Record track circuit ID on Track Circuit Data Sheet (Figure 6-5).

6.7.1. AF-902/904 350 or 500 MCM Track Circuit Tuning

For tuning of an AF-900/904 350 or 500 MCM track circuit, proceed with instructions in Table 6-7. The table lists the Operator's Action for tuning an AF-902/904 system using the front panel interface. The web page interface provides a means to perform all of these steps from the one tuning page in the Setup Mode, see Section 6.5.2.1.

Table 6-7. AF-902/904 350 or 500 MCM Tuning Instructions

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
1	Obtain track circuit frequency, (Fc) from Control Line Drawings.	Set both coupling units to nominal capacitor setting vs. frequency from Table 6-8.
2	Traverse restricted menu as described in Table 6-4 to [SET] [UP] Toggle *ENTER* for [TUNE][MENU]	Verify that coupling unit JMP9 {JMP16} is set to "NORM" position.
3	Toggle *ENTER* to automatically set direction of signal Receive West (RxW)	Using Fluke Scopemeter 97 in Vac mode – Monitor voltage at: TP2 and TP1 {TP5 and TP6}.
4	Toggle *ENTER* for [freq][0.0] Toggle *ADJUST to* set frequency to Fc – 400 Hz. Toggle *ENTER* for [pwr][xx%] Set pulsewidth to [pwr][50%]	Tune WEST coupling unit. Vary capacitance with JMP1-JMP8 {JMP10-JMP17} to peak voltage across: TP2 and TP1 {TP5 and TP6}

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
	Unit is now transmitting.	
5	Record final capacitance (E->W) on Track Circuit Data Sheet (Figure 6-5).	
6	Toggle ENTER to automatically set direction of signal Receive East (RxE).	
7	Toggle *ENTER* for [freq][0.0] Toggle *ADJUST to* set frequency to Fc – 400Hz. Toggle *ENTER* for [pwr][xx%] Set pulsewidth to [pwr][50%] Unit is now transmitting.	Tune EAST coupling unit. Vary capacitance with JMP1-JMP8 {JMP10-JMP17} to peak voltage across: TP2 and TP1 {TP5 and TP6}
8	Record final capacitance (E->W) on Track Circuit Data Sheet (Figure 6-5).	
9	Toggle ENTER to complete tuning sequence and return to [TUNE][MENU]	

6.7.2. Coupling Unit Tuning Theory

Changing the capacitance value in a coupling unit simultaneously tunes it to a different center frequency and changes the efficiency of the tuned circuit. As you decrease the capacitance value, both the center frequency and the circuit's efficiency increase. The result is that a capacitance value selected by peaking the signal at track circuit center frequency will actually result in a coupling unit that is tuned above track circuit center frequency.

Therefore, if you select a capacitance that gives the highest signal at some frequency below the desired operational center frequency (Fc) you will have better performance at Fc. The best overall offset is to set the tuning frequency to Fc – 400 Hz. If after calibration, you find that the variance is higher than 7% you may want to re-tune the coupling unit. You will need to reduce the capacitance by one or more increments to improve the variance. The new capacitance will not provide the peak signal level at Fc; instead, the center of the coupling unit's passband will be closer to Fc. To see if a change has been effective you must repeat the calibration of the AF-902/904.

If you find a track circuit that is difficult to tune well enough to provide a low variance, you can adjust the capacitance using the following fine-tuning procedure. Note that this is a more intensive process and should only be used if the normal tuning or the normal tuning plus a one or two step reduction in capacitance does not provide a satisfactory variance. The AF-902/904 system will accept variances up to 15% but it should be possible to achieve variances less than 10%.

To fine-tune a track circuit, you will need a means to measure the received signal, either at the coupling unit or at the AF-902/904. You can measure the signal in the same manner as with normal tuning. You will also find that fine-tuning is easier when using the web interface, but it can be done using the front panel.

First peak the received track signal as described above at Fc – 400Hz.

Stay in either the web interface or the front panel tuning mode.

Adjust the tuning frequency to Fc – 200 Hz (Space) and measure the received signal level with the AC voltmeter.

Then adjust the tuning frequency to Fc + 200 Hz (Mark) and re-measure the received signal level. Be sure that the transmission is in the correct direction. You must always tune at the receiver end.

If the Mark frequency is higher than the Space, reduce the capacitance in the coupling unit by one step.

Repeat measuring and adjusting one capacitance step at a time until the Mark and Space are near the same value. Remember that stepping the capacitance "one step" may involve selecting and deselecting capacitors. Also, note that at the higher frequencies, a small change in capacitance will have larger effect than at the lower frequencies.

If you change the capacitance and the Fc-200 (Space) frequency becomes greater than the Fc + 200 Hz (Mark) frequency, you are at or have passed the optimum capacitance.

Table 6-8. Coupling Unit (Nominal Capacitance Setting)

NOTE: FINAL TUNED SETTINGS WILL BE NOMINAL ± 2.0 μF (MICRO FARADS).								
FREQ.(FC)	**9.5kHZ**	**10.5**	**11.5**	**12.5**	**13.5**	**14.5**	**15.5**	**16.5**
NOM. CAP.	20.0 μF	17.33 μF	15.00 μF	13.00 μF	11.00 μF	9.47 μF	8.47 μF	7.33 μF

6.7.3. AF-902/904 350 or 500 MCM Rail Current Calibration

Table 6-9 contains the sequence of actions that must be performed to set the correct rail current for an AF-902/904 track circuit. The rail current is set by adjusting the transmitter's output power. The table lists the Operator's Action for setting the rail current using the front panel interface. The Setup Mode's Calibration page provides both a guide and the controls required to perform all of these steps, see Section 6.5.2.2.

Table 6-9. AF-902/904 350 or 500 MCM Calibration Procedure

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
1	Prior to starting a calibration verify that the Partner unit in an AF-902 system is turned OFF. Set Receiver tap to the 2 postion.	
2	Obtain track circuit frequency, (Fc) from Control Line Drawings.	

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
3	Traverse restricted menu as described in Table 6-4 to [SET][UP] Toggle *ENTER* for [TUNE][MENU] Toggle *MODE* to [CALI][BRAT] Toggle *ENTER* for [freq][xx.x] ADJUST frequency to Fc.	
4	Toggle *ENTER* to automatically set direction of signal Receive West (RxW). Toggle *ENTER* for [pwr][xx%]. Unit is now transmitting.	
5	Set I_{rail} for E to W. using a combination of selecting a transmitter tap and *ADJUST* [pwr][xx%],. (For I_{rail} setting, refer to Table 6-10 or Table 6-11).	Using a Spectrum Analyzer with a Current Probe, attach Probe to Center of 350 or 500 MCM Bond and monitor/report rail current (Irail) at West track bond.
6	Record I_{rail}, transmitter tap and pwr for E->W on Track Circuit Data Sheet (Figure 6-5).	NOTE: At cross-bonding points, the S-bond is doubled. The resulting I_{rail} is the sum.
7	Toggle *ENTER* to automatically set direction of signal Receive East (RxE).	Move to East track bond.
8	Toggle ENTER for [pwr][xx%]. Set I_{rail} for W to E, using a combination of selecting a transmitter tap and *ADJUST* [pwr][xx%],. (For I_{rail} setting, refer to Table 6-10 or Table 6-11).	Using a Spectrum Analyzer with a Current Probe, attach Probe to Center of 350 or 500 MCM Bond and monitor/report rail current (Irail) at East track bond.
9	Record I_{rail} and pwr on Track Circuit Data Sheet (Figure 6-5)..	
10	Toggle *ENTER* for [Levl][xx%]. Record receiver tap and Levl for W->E on Track Circuit Data Sheet (Figure 6-5). The receiver tap should be tap 2.	
11	Toggle *ENTER* for [Vari][x%] Variance should be between 0 and 15%. Record [Vari][x%] for W->E	
12	Toggle *ENTER* for [Shnt][151 - 171%] The system will set the Shunt level to a nominal 162% Record [Shnt][151 - 171%] for W->E when unshunted.	
13	Note: When SHUNT applied, check that [Shnt][xx%] < 100%. Record [Shnt][xx%] when shunted	Apply 0.2 ohms shunt to track at center of East Bond.

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
14	Toggle *ENTER* to automatically set direction of signal travel (East to West)	
15	Toggle *ENTER* for [Levl][xx%]. Record receiver tap and Levl for E->W on Track Circuit Data Sheet (Figure 6-5). The receiver tap should be tap 2.	
16	Toggle *ENTER* for [Vari][x%] Variance should be between 0 and 15%. Record [Vari][x%] for E->W	
17	Toggle *ENTER* for [Shnt][151 - 171%] The system will set the Shunt level to a nominal 162% Record [Shnt][151 - 171%] for E->W when unshunted.	
18	NOTE: When SHUNT applied, check that [Shnt][xx%] < 100%. RECORD [Shnt][xx%] when shunted.	Shunt track w/ 0.2ohms at West Bond.
19	If calibration is denied by the AF-902/904, the display will show "Denied". If calibration is accepted, the display returns to Set-Up. To exit, press ESC and then press Enter when "Sure ?" is displayed. Or press ESC to device calibration and return to Set-Up.	
20	If all parameters are CONFIRMED, unit will write setup parameters to EEPROM and [DONE]. Press RESET button for system reset.	
21	After reset, system front panel LEDs should show by being lit: ON-LINE, SELF, U-LOK COMM, LEVEL, DATA.	

Table 6-10. Rail Current Settings (350 MCM and 500 MCM Circuits)

NOMINAL I_{RAIL} CURRENT ± 2 MILLIAMP.								
FREQ.(FC) kHz	**9.5 kHz**	**10.5**	**11.5**	**12.5**	**13.5**	**14.5**	**15.5**	**16.5**
NOMINAL I_{RAIL} (mA)	105	95	87	80	75	70	65	60

Table 6-11. Rail Current Settings (Direct Injection Circuits)

NOMINAL I_{RAIL} CURRENT ± 2 MILLIAMP.								
FREQ.(FC) kHz	**9.5 kHz**	**10.5**	**11.5**	**12.5**	**13.5**	**14.5**	**15.5**	**16.5**
NOMINAL I_{RAIL} (mA)	105	95	87	80	75	70	65	60

For the AF-902, power down the Primary unit and repeat the calibration procedure for the Backup unit.

NOTE

Backup unit must have same MLOK address, TRK ID, Fc, password, and executive software version as the Primary unit.

6.7.4. AF-902/904 Cab Loop Current Calibration

Table 6-12 contains the sequence of actions that must be performed to set the correct rail current for an AF-902/904 track circuit. The rail current is set by adjusting the transmitter's output power. The table lists the Operator's Action for setting the loop current using the front panel interface. The Setup Mode's Calibration page provides both a guide and the controls required to perform all of these steps, see Section 6.5.1.5.

The AF-902/904 only transmits a track signal to the cab loop; it does not receive its signal so no occupancy detection can occur. Therefore upon completion of calibration the AF-902/904 system will not have a valid receive level, variance or shunt level. These parameters will display either a zero or "---" value on the front panel and web page displays.

Table 6-12. AF-902/904 Cab Loop Track Circuit Setup

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
1	Traverse restricted menu as described in Table 6-4 to **[SET] [UP]** Toggle *ENTER* for **[TUNE][MENU]** Toggle *MODE* to **[CALI][BRAT].** Toggle *ENTER* for **[freq][xx.x].** *ADJUST* frequency to **[freq][16.5]** .	Note: All cab loops employ a single coupling unit at the transmit end. The AF-902/904 system does not receive a signal back from the track.
2	Toggle *ENTER* for **[DIR][E->W]** (RxW). Toggle *ENTER* for **[pwr][xx%].**	Check cab loop wiring to ensure proper connections. AF-902/904 signal wire to 1,2 {4,5} . Cab loop wire to 7,8 {10,11}.
3	Select appropriate transmitter tap and *ADJUST* **[pwr][xx%]** to set I*Cabloop* to 275mA for Cab loop.	Using a Spectrum Analyzer with a Current Probe, attach probe to cab loop wire and monitor/report loop current (I*loop*) to the Train Control and Communications Building (TCCB).
4	Record I*loop*, transmitter tap and pwr for CAB LOOP on Track Circuit Data Sheet (Figure 6-6).	If location is a double crossover, proceed to other cab loop.
5	Toggle *ENTER* for **[DIR][W->E]** (RxE).	
6		Check cab loop wiring to ensure proper connections. AF-902/904 signal wire to 1,2 {4,5} . Cab loop wire to 7,8 {10,11}.
7	Toggle *ENTER* for **[pwr][xx%].** *ADJUST* **[pwr][xx%]** to the same "pwr" value set in step 3. Check that the I*Cabloop* > 250mA.	Using a Spectrum Analyzer with a Current Probe, attach Probe to Cab loop wire and monitor/report loop current (I*cabloop*) to TCCB.

STEP	AF-902/904 OPERATOR'S ACTION	TRACK/COUPLING UNIT TECHNICIAN'S ACTION
8	Record I*cabloop* and pwr on Cab Loop Circuit Sheet.	
9	If calibration is denied by the AF-902/904, the display will show "Denied". If calibration is accepted, the display returns to Set-Up. To exit, press ESC and then press Enter when "Sure ?" is displayed. Or press ESC to device calibration and return to Set-Up.	

Table 6-13. AF-902/904 Direct Injection Track Circuit Setup

STEP	AF-902/904 OPERATOR	TRACK/COUPLING UNIT TECHNICIAN(S)
	Proceed step by step with the calibration procedure in Table 6-9.	Proceed step by step with calibration procedure in Table 6-9. Exception Notes: (STEP 4 AND STEP 8) Check coupling unit wiring. AF-902/904 signal wire to 1, 2 {4, 5} Track Inject wire to 6, 8 {9, 11} I_{rail} settings to be done with 0.20 ohm shunt in place across rail at receive end. Current transformer on shunt.

6.8. Test Documentation and Data Sheets

The results of the setup and test procedures must be fully documented using the approved circuit plans and the test Data Sheets. For specific information concerning a particular location's AF-902/904 installation, refer to that location's circuit drawings, Book of Plans, test record sheets, and any other installation data that may be available. The type of information that is available may vary and depends on the railroad or transit authority's record keeping policy.

6.9. Example of a Record Keeping Policy

The approved circuit test plans are used to record the results of the setup procedure. A circuit that has been tuned only should be checked in blue. A circuit that has been both tuned and calibrated should be checked in green. If corrections to the circuit plans are required as a result of any procedure, the Test Engineer should document the changes using Yellow = Out and Red=In color coding. In addition, the test engineer is required to initial and date the changes and to further document the changes by using a Standard Discrepancy/Action Item List with the installation test procedures to fully describe the discrepancy and the action taken.

The Data Sheets provided at the end of this section are used to record the results of the tests. The top portion of the Data Sheet should be filled in before beginning the test. As part of this, the test engineer should record the track circuit length and the approximate cable length from the AF-902/904 to the nearest coupling unit.

Refer to the following test data sheets:

- Figure 6-5. AF-902 Track Circuit Data Sheet
- Figure 6-6. AF-902 Cab Loop Data Sheet
- Figure 6-7. AF-904 Track Circuit Data Sheet
- Figure 6-8. AF-904 Cab Loop Data Sheet.

AF-902 TRACK CIRCUIT DATA SHEET								
Location _____ Track Circuit Length (65-1000 ft, 20-305 m)_____Feet/Meters Cable Length to Nearest Bond (6000 ft max, 1800 meters max)_____Feet/Meters Track Circuit ID# (1-4095)_____ MLOK Address (1-127)_____ Peer Address (1 - 65535) _____								
Tuning Procedure								
Frequency (kHz)	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Direction	West to East				East to West			
Coupling Unit Capacitance	_____µF				_____µF			
Calibration Procedure								
Transmitter Tap Setting	1	2	3	4	5			
Direction	West to East				East to West			
AF-902 Unit	Primary		Backup		Primary		Backup	
[pwr] Pulse Width (25% - 95%)	_____%		_____%		_____%		_____%	
$^{I}RAIL^{(mA)}$	_____mA		_____mA		_____mA		_____mA	
Receiver Tap Setting	2							
Receiver Level [Levl] [Vari]	_____% 8-55% _____% 0-15%		_____% 8-55% _____% 0-15%		_____% 8-55% _____% 0-15%		_____% 8-55% _____% 0-15%	
Shunt Level [Shnt] Unshunted [Shnt] Shunted	_____% 151 - 171% _____% < 100%		_____% 151 - 171% _____% < 100%		_____% 151 - 171% _____% < 100%		_____% 151 - 171% _____% < 100%	
Inspector_____ Date_____								

Figure 6-5. AF-902 Track Circuit Data Sheet

AF-902 CAB LOOP DATA SHEET								
Location _____ Cable Length to Cab Loop Coupling Unit (65-1000 ft, 20-305 m)_____Ft/m Track Circuit ID# (1-4095)_____ MLOK Address (1-127)_____ Peer Address (1-65535) _____								
Calibration Procedure								
Frequency *(kHz)*	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Transmitter Tap Setting	1		2		3		4	5
Direction	West to East				East to West			
AF-902 Unit	Primary		Backup		Primary		Backup	
[pwr] Pulse Width (25% - 95%)	_____%		_____%		_____%		_____%	
$I_{CABLOOP}$ (mA) 250mA < I < 300mA	_____mA		_____mA		_____mA		_____mA	
Receiver Tap Setting	2 (Not Applicable)							
Inspector_____ Date_____								

Figure 6-6. AF-902 Cab Loop Data Sheet

AF-904 TRACK CIRCUIT DATA SHEET								
Location _____ Track Circuit Length (65-1000 ft, 30-305 m) _____Feet/Meters Cable Length to Nearest Bond (6000 ft max, 1800 meters max)_____Feet/Meters Track Circuit ID# (1-4095)_____ MLOK Address (1-127)_____ Peer Address (1-65535) _____								
Tuning Procedure								
Frequency (kHz)	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Direction	West to East				East to West			
Coupling Unit Capacitance	_____µF				_____µF			
Calibration Procedure								
Transmitter Tap Setting	1	2	3	4	5			
Direction	West to East				East to West			
[pwr] Pulse Width (25% - 95%)	_____%				_____%			
$^{l}RAIL^{(mA)}$	_____mA				_____mA			
Receiver Tap Setting	2							
Receiver Level [Levl] [Vari]	_____% 8-55% _____% 0-15%				_____% 8-55% _____% 0-15%			
Shunt Level [Shnt] Unshunted [Shnt] Shunted	_____% 151 - 171% _____% < 100%				_____% 151 - 171% _____% < 100%			
Inspector_____ Date_____								

Figure 6-7. AF-904 Track Circuit Data Sheet

AF-904 CAB LOOP DATA SHEET								
Location _____ Cable Length to Cab Loop Coupling Unit (65-1000 ft, 20-305 m)_____Ft/m Track Circuit ID# (1-4095)_____ MLOK Address (1-127)_____ Peer Address (1-65535) _____								
Calibration Procedure								
Frequency (kHz)	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Transmitter Tap Setting	1		2		3		4	5
Direction	West to East				East to West			
[pwr] Pulse Width (25% - 95%)	_____%				_____%			
$I_{CABLOOP}$ (mA) 250mA < I < 300mA	_____mA				_____mA			
Receiver Tap Setting	2 (Not Applicable)							
Inspector_____ Date_____								

Figure 6-8. AF-904 Cab Loop Data Sheet

7. LIGHTNING PROTECTION RECOMMENDATIONS FOR AF-902/904 INSTALLATIONS

All installations of AF-902/904 Systems should consider a lightning protection plan that includes the protection of both the power wiring and the track signal wiring. The following sections are a checklist of wiring configurations and recommended protection.

7.1.1. Primary AC Line Protection

Primary AC Line Protection refers to the protection of the AC Mains at the Service Entrance.

7.1.1.1. Split Single Phase 120/240VAC Feed

This is a standard split single phase feed. The center of the 240VAC split is utility (earth) grounded.

The recommended Primary Stage AC Line Protection is ASTS USA Part Number J7927360147.

This device is to be mounted directly to the Breaker Panel and wired to the main feeders through dedicated breakers.

7.1.2. 120VAC Isolated (Ungrounded) Feed

Some Signal House AC Feeds are brought into the House through an Isolation Transformer. The House side of that transformer will be a floating (neither side grounded), 120VAC feed.

If this isolated 120VAC feed never leaves the House, the Primary Protection device to be used at the Service Panel is ASTS USA Part Number J7927360144.

If this isolated 120VAC is distributed throughout the House and leaves the House, the Primary Protection device to be used at the Service Panel is the ASTS USA Part Number J7927360178.

7.1.3. Secondary AC Line Protection

The Secondary AC protection is for those lines carrying the “protected” AC Power coming into the House, to remote devices or locations outside the Signal House. This power is usually located on the main Terminal Board and on adjacent terminal posts. The preferred device to be used as Line-to-Line protection is the ASTS USA Part Number J7927360181 but the ASTS USA Part Number J7927360182 can also be used in most applications.

In the event a protected isolated AC feeder is sent outside the Signal House, then those lines would also need to be protected Line-to-Ground. In either case, the protection devices are the same as those mentioned above.

7.1.4. Signal Wiring

All track wires between the house and the AF-902/904 Coupling Units should be protected in a Line-to-Ground configuration at the Main Terminal Board. The recommended Line-to-Ground Protection Device is the ASTS USA Part Number J7927360180.

This device is a Gas Tube Arrester Assembly. It is designed to mount on standard AAR Terminal posts that are spaced 2-3/8 inches center-to-center.

7.1.5. Communication Ports

Any communication lines leaving the Signal House should have Line-to-Ground Protection using the ASTS USA Part Number J7927360180.

7.1.6. Microlok II Lightning Protection Considerations

Since the Ansaldo MICROLOK II Controller interfaces to the AF-902/904, it is important to consider protection for the controller. In particular, protection should be provided for the House Battery Feed to the MICROLOK II Controller. This will include both Line-to-Line (L-L) and Line-to-Ground (L-G) protection methods.

The recommended L-L protection device for the 12VDC Power to the MICROLOK II is the ASTS USA Part Number J7257090519. This protector mounts onto standard AAR Terminal Posts on 1 inch centers.

The recommended L-G protection devices are Gas Tube Arrester assemblies, ASTS USA Part Number J7927360180.

Be sure to have this protection as close to the MICROLOK II Cardfile as possible.

NOTE

To optimize the protection, the lines or line pairs must terminate at the protection devices and from there, continue on to the equipment. The protection device must not be connected via branch (Tee) wiring.

8. PREVENTIVE MAINTENANCE

8.1. Introduction

This section describes the maintenance tasks required for the AF-902/904 track circuit unit, coupler, and AF-902/904 350 or 500 MCM bond. These preventive maintenance tasks are to be performed on as-scheduled basis, whereby the components are inspected, cleaned, tested, and adjusted at periodic intervals to ensure the proper operation of the AF-902/904 unit.

8.2. Importance of Preventive Maintenance

Regular Preventive Maintenance Inspection (PMI) can prevent failures and system malfunctions.

Maintenance personnel are responsible to keep the AF-902/904 unit in safe and satisfactory operating condition at all times. This is accomplished through regular inspections, cleaning, testing, and required adjustments of the unit. By maintaining up-to-date repair and PMI records, and reviewing the history of these activities, maintenance schedules can be set to prevent circuit performance deterioration. PMI can lead to the discovery of questionable conditions before major malfunctions can occur, potentially causing train traffic problems and eventually total train stoppage.

Track circuit bobbles can be minimized by both corrective and preventive maintenance practices. Preventive maintenance is the monitoring of specific parameters in a timely manner. Corrective maintenance is the replacement of a failed unit in a timely fashion.

There are several key parameters of the AF-902/904 track circuit that can be monitored to determine the health of the track circuit. These parameters are displayed by the AF-902/904 and can be checked by the maintainer.

The several major AF-902/904 track circuit parameters to be monitored are:

- Received Signal Level - This parameter is important because it verifies that the received signal level is within the operating range of the receiver circuit. An unoccupied track circuit should have a received signal level between 8 and 55%.
- Shunt Level – As with the Received Signal Level this value indicates the track signal level. If the value changes to near 100% due to changes in ballast conditions, a recalibration may be required or a false occupancy could be indicated.
- Variance - This parameter can be used to determine whether the coupling unit is tuned correctly or a coupling unit has failed. Variance can also indicate whether interference from another source is becoming a problem in the reliable operation of the track circuit.
- Events – The web page Events page displays the errors, warnings, and operational events that have been detected by the AF-902/904 TCS. The most recent display is displayed first.

8.2.1. Received Signal Level

A model of the AF-902/904 track circuit can be represented as shown in Figure 8-1. The rails are represented by impedance Z_R. ‘Bal’ is the ballast resistance of the track circuit.

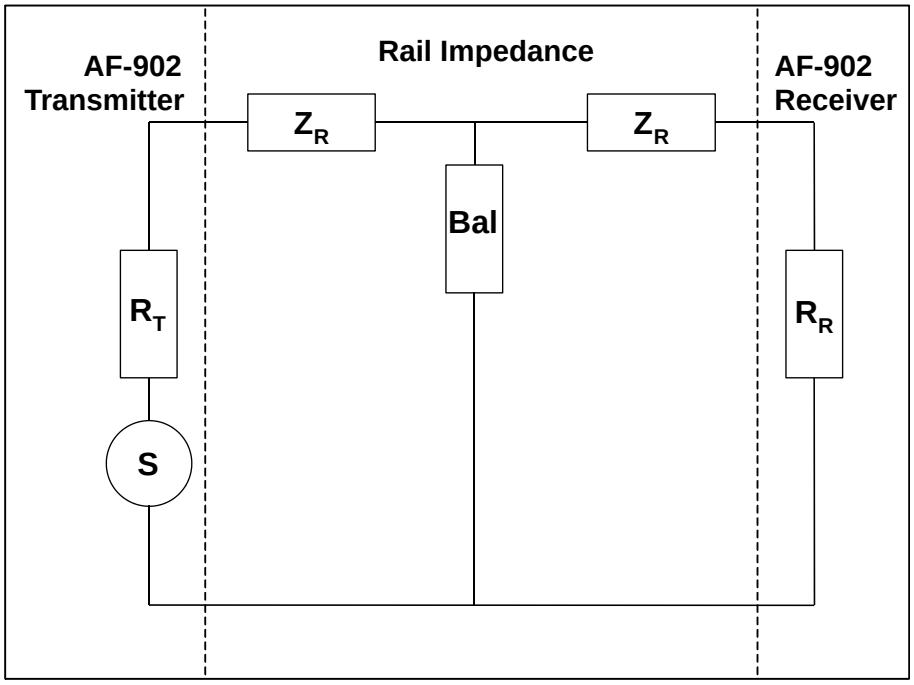


Figure 8-1. Direct Injection AF-902/904 Track Circuit

The AF-902/904 receiver and its coupling unit are represented as impedance R_R and the AF-902/904 transmitter and its coupling unit are represented as a R_T and source voltage S.

The value of the ballast resistance changes with time and the conditions of the ballast material that supports the rails. The lower the value of ballast resistance, the lower the signal magnitude received at the input of the AF-902/904 receiver.

The signal strength received at the input of the receiver is displayed on the web page and front panel of the AF-902/904. The signal strength is displayed as a percentage of a shunt condition. A value of 100% represents the highest received signal level (highest rail to rail impedance) that will be detected as a shunt condition. Thus, values of signal strength should be much greater than 100% when the track circuit is not occupied. Typical values of between 151-171% are normal.

If the ballast becomes low, the percent displayed will be less than the normal value.

8.2.1.1. Calibration During High-Ballast Conditions

The AF-902/904 track circuit is initially adjusted with high ballast resistance. The inherent design of the AF-902/904 track circuit ensures that it functions correctly over a range of 100%-162%, represented by a term called overdrive. This overdrive is illustrated in Figure 8-2.

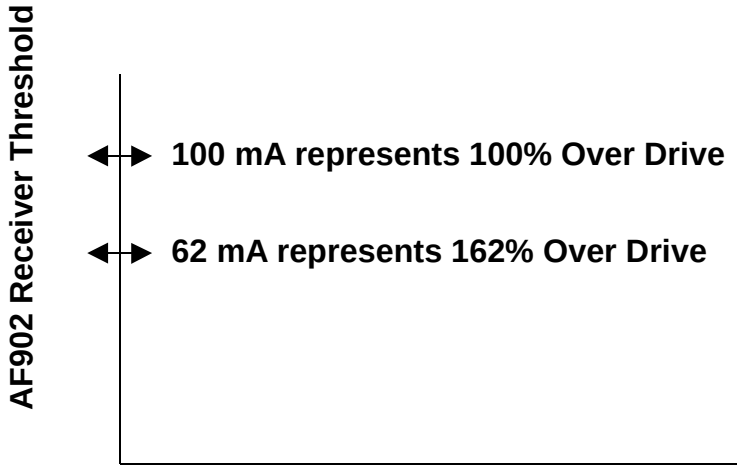


Figure 8-2. Adjustment at High Ballast

When the track circuit is initially adjusted (for example, a 10.5 kHz circuit) with high ballast resistance, the threshold level of the track circuit's receiver is 100 mA. The 100 mA represents an overdrive value of 1 or, expressed in percentage, 100%.

With only an overdrive of 100% (or 1), the track circuit would become occupied if the ballast resistance changes to any lower value than assumed at the initial adjustment value. So it can operate over a changing ballast value, overdrive is added to the track circuit. A track circuit with no overdrive would operate very unreliably.

The overdrive can be achieved via increasing the source voltage OR decreasing the threshold value of the receiver. With the AF-902/904 track circuit, overdrive is obtained by changing the threshold of the receiver. Thus in the figure above, an overdrive value of 1.62 (or 162%) is obtained by adjusting the receiver threshold to 62 mA. Note that the magnitude of overdrive is selected as a function of frequency, shunting sensitivity, minimum ballast, rail-to-rail voltage, etc.

Once the track circuit is adjusted with high ballast resistance, the received signal strength can change as the ballast changes. The value of the received signal strength is displayed on the web page and front panel of the AF-902/904.

If the track circuit is recalibrated, the threshold of the receiver will be changed. For example, if the ballast value is low and the received signal level is 60%, performing recalibration will adjust the threshold of the receiver to a new value.

Figure 8-3 shows the new threshold of the receiver. The new value is now 38 mA, which represents a 162% overdrive value.

8.2.1.2. Calibration During Low-Ballast Conditions

If after a calibration, the ballast would change back to a very high value, the overdrive may be much more now than the 162%. See Figure 8-4.

As can be reasoned, the 38 mA threshold now represents an overdrive of 263% (2.63 = 100 mA / 38 mA). Because of the safety implications, the value of overdrive is continuously monitored by

the AF-902/904 track circuit. If this value exceeds approximately 180%, the track circuit is 'turned off' for a period of time and Error is recorded.

The calibration function, when performed with low ballast, does not present a safety issue, only a reliability issue in operation. The calibration should only be performed when the ballast is nominal or high. The overdrive of the AF-902/904 should be sufficient to permit the track circuit to operate over the complete ballast range.

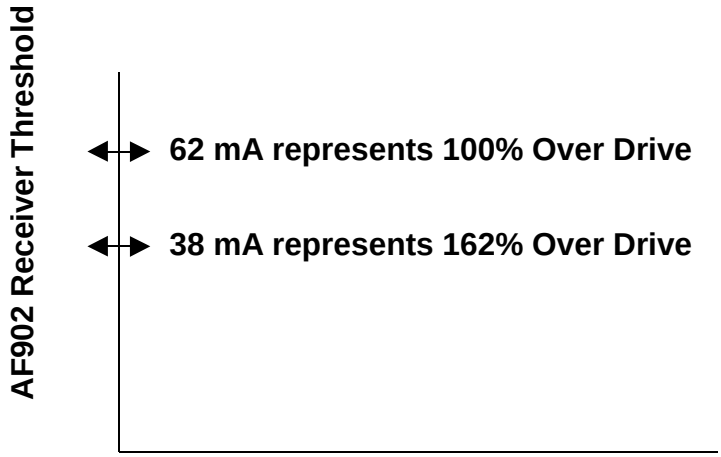


Figure 8-3. Adjustment at Low Ballast Auto Calibration

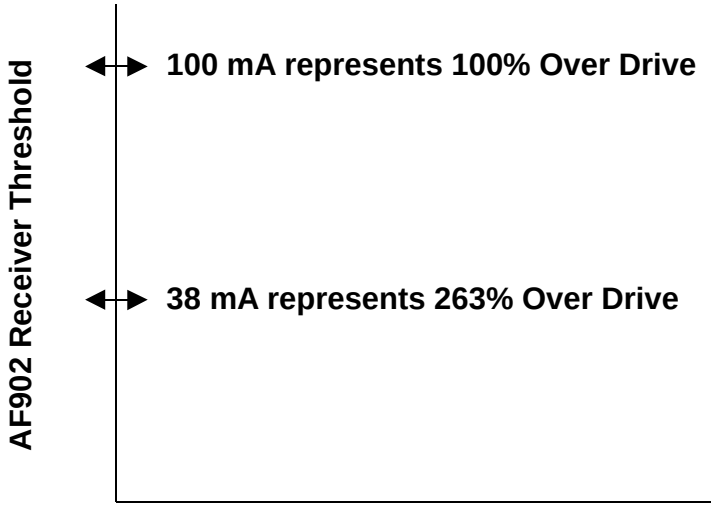


Figure 8-4. If Ballast Becomes High Auto Calibration

8.2.2. Variance

Variance is a measurement of the differences in the amplitudes in the wayside coupling unit between the Mark and Space frequencies. The coupling unit is a LC circuit tuned to a specific frequency.

If the variance is 0%, both the Mark and Space frequency amplitudes are identical. See Figure 8-5.

The AF-902/904 system employs two type of coupling units. One type of coupling unit is used with S-bond, O-bond, and I-bond track circuits and requires being tuned to the specific operating carrier frequency. The second type of coupling unit is used for all direct injection, single rail AF-902/904 track circuit configurations. The direct injection coupling unit does not require tuning.

8.2.2.1. S-Bond, O-Bond, and I-Bond Track Circuits

If no in-band interference is present, the variance value obtained from the AF-902/904 is a measurement of how well the wayside coupling unit is tuned.

If the coupling unit is slightly off in tuning, the variance is several percent. Ideally, the variance should be zero. However, values up to 15% are acceptable.

8.2.2.2. Direct-Inject Track Circuits

Because the direct injection coupling unit is not tuned, the variance measured with these track circuits is very low. Typical values are between 0% and 5%, depending on the cable length between the room and field-located coupling unit.

With no in-band interference, the variance value is a constant magnitude. However, if in-band noise is present, the variance displayed by the AF-902/904 will vary between values, because the noise adds and subtracts to the Mark and Space signal amplitudes.

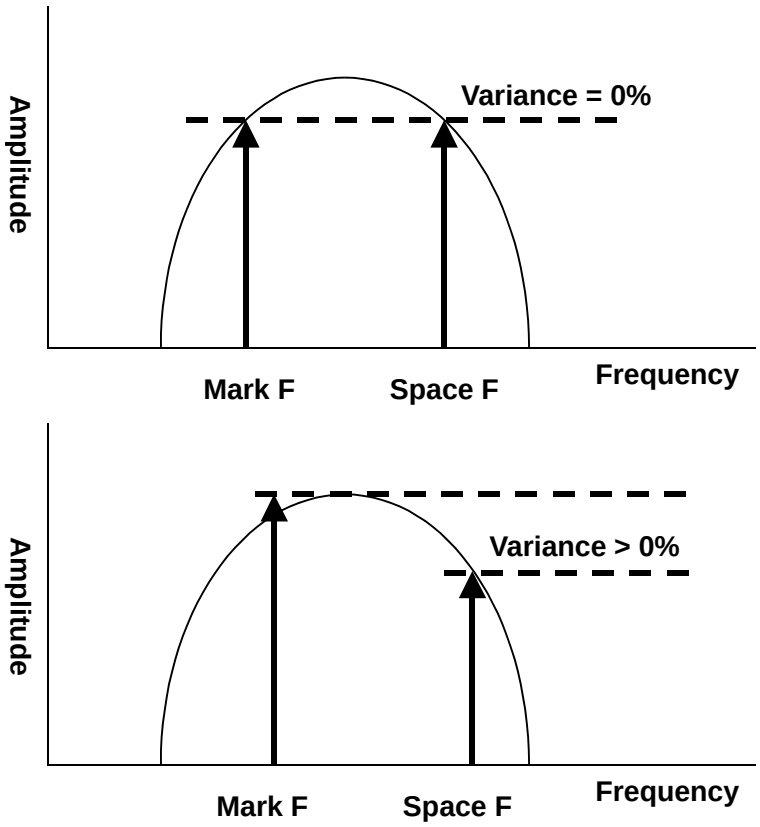


Figure 8-5. Meaning of the 'Variance' Parameter

8.2.3. Event Code Monitoring

The web page interface provides a display of errors, warnings, and operational events detected by the TCS. The Event threshold level can be adjusted to log only errors if set to 0, errors and warnings if set to 2 and errors, warnings and events if set to 5. Higher levels will show and excessive number of events and are only useful for advanced troubleshooting.

8.3. Preventive Maintenance Tasks

Preventive maintenance tasks are to be performed on a scheduled basis, as described in this subsection, to ensure reliable and safe operation of the AF-902/904 Track Circuits.

8.3.1. Initial Preventive Maintenance Tasks

Table 8-1 lists the key preventive maintenance actions to be taken during the early phases of operation of the AF-902/904 Track Circuit units or until a regular and stable maintenance regimen is established for all subsystems of the transit system that affect the operation of the track circuits. The time intervals recommended in Table 8-1 can then be made longer.

Table 8-1. Key Preventive Maintenance Actions

Action Item	Time Period	Comments
Review the received signal level.	Once every two weeks **NOTE**: If levels are consistently less than 160%, the Variance measurement should not be performed until the receiver levels are stable.	Logs should be kept. If low values of received levels are consistently viewed, the cause of these low levels must be analyzed and the problem solved.
Collect and analyze the event codes for all track circuits.	Once every two weeks	Clear memory after reviewing the event codes.
Switch over to the standby units.	Once every four weeks	This ensures that the reserve unit will come on line. Once the reserve unit is on line, the normal unit can be switched to be on line. This test is to ensure the system's availability remains high.
Check variance values.	Once every four weeks **NOTE**: The shunt level should be approximately 150% to 160% before this measurement is made	Values should range between 0% and 5%. If the values are greater than stated, the coupling unit should be retuned. If the variance is still high after retuning, analysis of other causes should be investigated. The current Variance and Shunt Levels are displayed at the bottom of the AF-902/904 MessageData "home" webpage. The readings should be observed for up to a minute to determine if the variance is steady (not changing because of interference).

8.3.2. Equipment Cleaning Procedure

Cleaning is necessary to remove all accumulated dirt and other foreign matter from the AF-902/904 track circuit unit, coupler, and track bonds that form the AF-902/904 system. A six-month cleaning interval is recommended. While cleaning any of these system components, the maintainer must exercise the necessary caution in order not to damage or dislodge any wires or connectors.

8.3.2.1. Cleaning Materials

The following cleaning materials are required to effectively clean the unit and remove unwanted debris. The cleaning supplies are of commercial grade and may be purchased from any cleaning supplier.

Item	Use
Household Cleaner	Mild liquid cleaner used to clean exterior surfaces.
Lint-Free Cloths	Used to clean and dry exterior surfaces.
Soft Bristle Brush	Used to remove dust and foreign matter from terminal blocks, electrical connections, and equipment surfaces.
Air in Aerosol Can	Used to blow out dust and foreign matter from delicate components and electrical surfaces.

8.3.2.2. Equipment Room Cleaning Procedures

When cleaning the AF-902/904 track circuit cardfile in the equipment room, safety warnings should be adhered to and precautions should be taken to prevent personal injury.

WARNING

Hazardous voltages and current may be present. Use extreme caution when working near exposed terminals. Never use wet cloths near exposed electrical equipment.

To clean the cardfile, perform the following procedure:

1. Remove dust and dirt from all accessible surfaces using a soft bristle brush.
2. Using compressed air, blow out dust and dirt from inaccessible areas around terminal blocks, fuse holders, and other areas where live electrical conductors are exposed.

CAUTION

When using compressed air to blow out dirt and dust particles from cardfiles, always direct air at an angle relative to the PCBs so that damage will not occur to the mounted components.

3. Wipe exterior and interior surfaces, not exposed to electrical circuitry, with a lint-free cloth dampened with a solution of water and household cleaner to remove all dirt and foreign matter.
4. Dry all surfaces with lint-free cloth.
5. Using compressed air or a soft bristle brush, remove all dust and dirt particles from cardfiles, wiring and other areas that may not be accessible using standard cleaning methods.

8.3.3. Track Circuit Inspection

Track circuit inspection should take place at least once a year or more frequently, if desired.

This inspection procedure consists of observing the physical condition of the equipment and performing any actions or operations that may affect the function of the item under test. It may be necessary to take appropriate cleaning steps prior to inspection. Knowledgeable maintenance personnel who are familiar with the operational functions of the system should inspect for appearance, smell, sound, and feel of the equipment. Any of these observation methods can alert the maintenance personnel of fault conditions.

8.3.3.1. AF-902/904 Room Equipment

The following inspection procedures should be used:

1. Check the AF-902/904 front panel to ensure that all controllers and power supplies are properly and fully inserted.
2. Check that the cable connections to the rear of the cardfile are intact, tight, and free from nicks, cuts, and fraying.

8.3.3.2. Track Side Components

The following inspection procedure should be used:

1. Check all cable connections from the AF-902/904 cardfile connectors on the rear panel to the track circuit coupling units for any signs of nicks, breaks, kinks, corrosion, or fraying.
2. Check all cable connections from the AF-902/904 coupling units to the appropriate 350 or 500 MCM bond locations for any signs of nicks, breaks, kinks, corrosion, or fraying.
3. Verify that the inside of the track coupling unit is free from water and any moisture.
4. Check all 350 or 500 MCM bond connections for damage, corrosion, and tightness.
5. Check that all PVC tubing is properly secured against the 350 or 500 MCM cable.
6. Check all wayside components for any signs of physical damage, such as cracks in loop PVC tubing, etc. Check all mounting hardware for tightness and to see if any of the hardware needs to be replaced.
7. Remove any debris or foreign objects that may hinder the proper operation of the AF-902/904 track circuit system.

NOTE

If any fault condition is observed during inspection, it should be corrected immediately. Inform your supervisor at once for proper procedures.

8.3.4. Track Circuit Checks

A regular schedule should be established to verify every AF-902/904 track circuit's shunt level. The interval of the inspection will vary for each installation. Track circuits with poor or changing ballast conditions will require more frequent inspection.

A calibrated 0.2 ohm should be placed at the entry, center, and exit point of the each circuit while monitoring the shunt level and occupancy status of the TCS under test. The shunt level should drop below 100% at each location and occupancy should be indicated. The shunt level and occupancy can be monitored on the front panel display or by using the web server interface to the maintainer PC. Conduct tests for both TCS units in the AF-902 system.

It is not recommended that track circuits be routinely recalibrated if they are able to accurately detect the test shunt. As described in Section 8.2.1, the receive level can be affected by extreme ballast conditions, Therefore, recalibration should only be done at nominal ballast conditions.

8.3.4.1. Track Circuit Sensitivity

As part of the calibration portion of the routine, the regularly scheduled PMI will require testing for track circuit sensitivity. Before this test can be performed, tuning should be performed in order to tune the two associated coupling units to the desired track circuit frequencies (9.5, 10.5, 11.5, 12.5, 13.5, 14.5, 15.5, 16.5 kHz). The tuning frequency and track circuit sensitivity information can be found on the initial installation track circuit Data Sheet.

9. TROUBLESHOOTING

9.1. Introduction

This section describes the methods and procedures that can be used by qualified maintainers to identify, test, isolate, and repair faulty conditions in the AF-902/904 track circuit. All repairs will be to the Lowest Repairable Unit (LRU) that is practical for field maintenance situations.

9.2. Approach to Troubleshooting

The process of isolating a failed or faulty component(s) is called "troubleshooting." This is a carefully planned approach that will lead to identifying the cause of a system's stoppage or abnormal operation.

The responsibility of the maintenance personnel is to locate the cause of failure and repair the condition as soon as possible. This can be accomplished only if a systematic approach is taken by qualified personnel who are familiar with the test equipment and testing procedures. Basic concepts to apply to any troubleshooting situation are listed in Table 9-1.

Table 9-1. Basic Troubleshooting Concepts

CONCEPT	SUGGESTED ACTIONS
Observe and analyze the symptom.	The symptom may identify the site location, sub-system, hardware vs. software causes, or cable/communications link.
Sectionalize the system.	If it is difficult to identify the faulty subsystem, the maintainer should proceed to sectionalize the system in halves until the site and subsystem are known.
Localize the fault within the Subsystem.	Identify the LRU and test by using available software or control panel diagnostics.
Isolate the cause.	Continue troubleshooting the LRU for modular replacement or adjustment.
Repair the failure.	The trouble can be corrected by adjustment, component replacement, or wire repair.
Check repair and operation.	Verify that the repair has been properly done by checking the operation of the system for any other fault symptoms and irregularities. Never assume that the first fault found was the only fault.

The priority of field maintenance personnel is to get the system up and running. This calls for prompt action, fault isolation, and trouble repair. To achieve this, the Maintainer may not be required to troubleshoot beyond the modular component level, commonly referred to as the LRU level. The entire troubleshooting process can be expedited by performing "Go-No Go" replacement checks and repair.

The key to identifying the probable cause of failures is the use of a process of elimination. This is the most effective and efficient approach to troubleshooting and fault isolation on any system.

9.3. Troubleshooting Procedures

9.3.1. Fault Symptoms

Every abnormal symptom is a result of a cause that has a remedy. The maintainer must determine how severe the cause (how much damage resulted), and how difficult the repair process (quick replacement versus system down-time). Table 9-2 gives a brief listing of symptoms, probable causes, and suggested remedies. These remedies are to the LRU level to assist in swift repair.

The ATC system notifies the train dispatcher and general system maintainer of problems by an AF-902/904 off-line or on-line alarm.

- The AF-902/904 off-line alarm is an indication that either the Primary or the Standby unit has failed/reset. If the Primary unit fails, then a fail-over occurs to the Standby unit. This event most likely causes a sequential occupancy. If the AF-902/904 off-line alarm is toggling off and on, then most likely the Standby unit is constantly resetting itself.
- The AF-902/904 on-line failure alarm turns on only after an AF-902/904 off-line failure, indicating that both AF-902/904 units have failed. This causes an occupancy display and stops train movement.

The AF-902/904 FSK track circuit system notifies the maintainer of most faults through its front panel indicators. Before performing any troubleshooting tests or diagnostics, the maintainer should first make the following observations:

- Are the power supply LEDs ON?
- Are the TCS, and power supply LEDs NORMAL?
- Is a backplane connector loose or disconnected?
- Is there any physical damage anywhere near the track circuit equipment?

If no obvious faults are observed, the maintainer should proceed with the standard troubleshooting techniques.

Table 9-2. Troubleshooting

SYMPTOM	PROBABLE CAUSE	SUGGESTED REMEDY
Track is unoccupied, but low or no receive signal.	Broken 350 or 500 MCM bond.	Check track bond and cabling.
	Bad coupling unit.	Check input and output cable connectors to coupling unit.
	Defective TCS.	Remove and replace.
	Conductive debris across track.	Inspect and remove debris.
Intermittent track occupancy indications.	Signal threshold level setting on TCS not correct.	Adjust or replace.
Receiver levels are low.	Track carrier frequencies are out of specification limits.	Check tuning procedure.
		Verify coupling unit adjustment.
When performing the tuning or calibration procedures, the proper carrier frequency cannot be achieved.	Adjacent track circuit ON.	Turn power OFF of adjacent track circuit.
	Adjusting wrong circuit in coupling unit.	Check for correct TX or RX side of track circuit.
HEALTH indicator OFF	Primary or Backup unit is faulty.	Replace defective module.

The AF-902/904 is continually running diagnostics on the entire track circuit system. Any failure of these diagnostics will signal the MICROLOK II unit of track occupancy. This will maintain the track circuit in a safe state, not allowing any train traffic until the system is again operating correctly.

9.4. Front Panel Indicators and Controls

9.4.1. AF-902/904 TCS

This front panel consists of two, four-character alphanumeric scrolling displays, and four up-down SPDT toggle switches that can be used to enter and examine data used in the setup and operation of the track circuit. Eighteen discreet LEDs provide additional information. In addition, the web page interface provides all of the front panel information in a more convenient format. See Section 4.2

Figure 9-1 shows the indications, connectors, and controls on the front panel of the TCS.

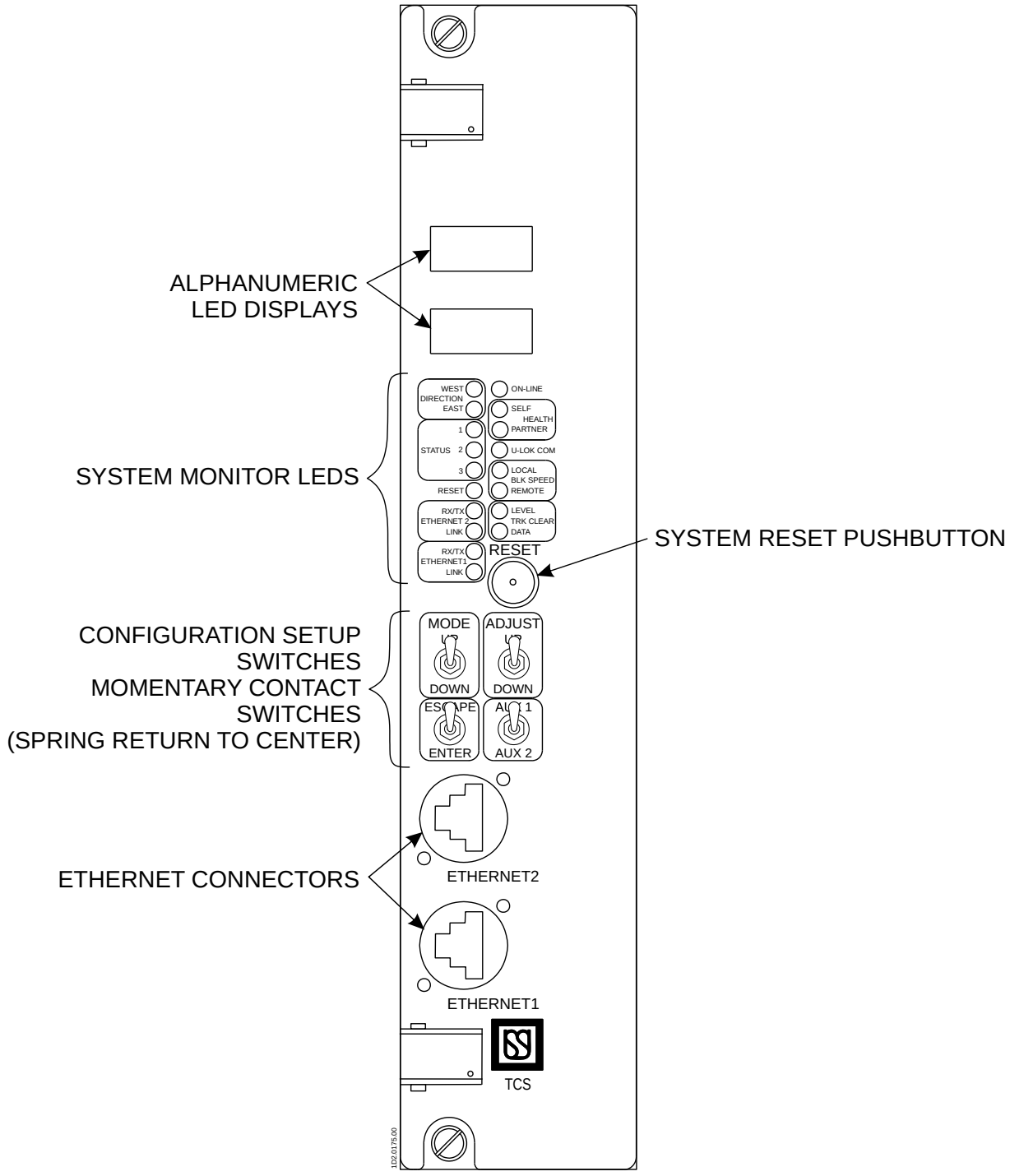


Figure 9-1. AF-902/AF-904 TCS Front Panel

9.4.2. AF-902/904 Power Supply

The power supply was designed specifically for application in the AF-902/904 track circuit cardfile.

Two separate power switches are on the front panel. They are locking-lever type switches that need to be pulled out in order to toggle. Test points and LED indicators for each supply output (six total) are provided and are accessible through the front panel.

Each Power Amplifier Transformer output is also accessible at the front panel. All test points are fed through appropriate current limiting resistors to avoid shorting the outputs.

Figure 9-2 shows the indications, test points, and controls on the front panel of the Power Supply.

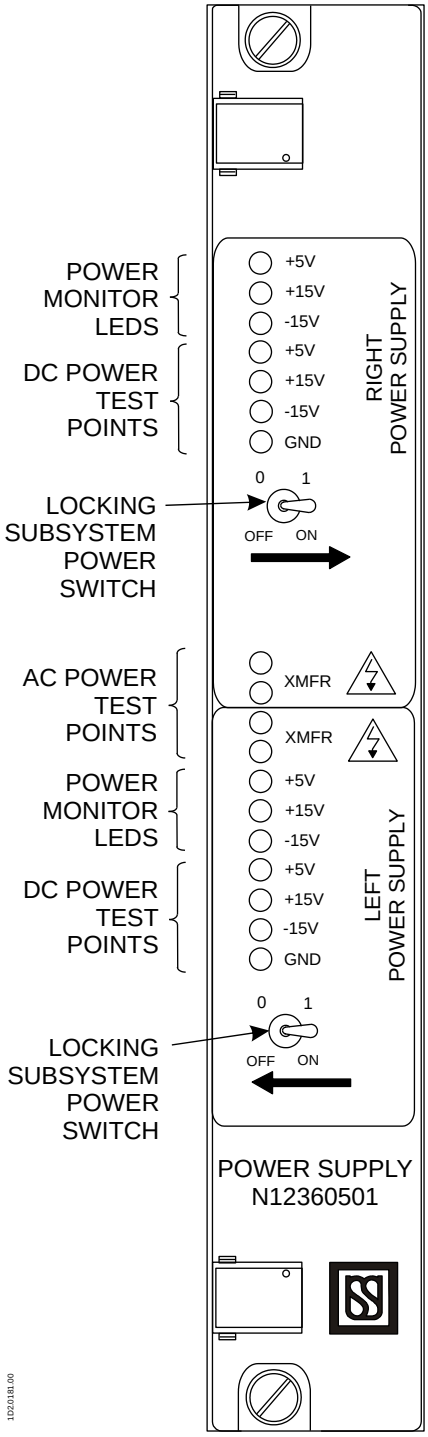


Figure 9-2. AF-902/904 Power Supply Front Panel

10. CORRECTIVE MAINTENANCE

10.1. Introduction

This section describes the procedures necessary to access, replace, and repair the AF-902/904 track circuit system's components to the LRU level that is practical at the field maintenance level.

Corrective maintenance is an unscheduled process initiated by a system failure or resulting from unsatisfactory preventive maintenance data. After a system fault has been localized by performing the necessary troubleshooting and diagnostic testing, the maintainer is required to adjust or replace the component. Following the component adjustment or replacement, the maintainer is required to perform system repair verification.

10.2. Replacement Repair

The AF-902/904 track circuit system comprises three major components:

- AF-902/904 FSK cardfile
- AF-902/904 track coupling unit
- 350 or 500 MCM bond

The suggested repairs at the field level are designed to minimize system downtime and reduce the need for specialized or sophisticated test equipment.

10.2.1. AF-902/904 TCS and Power Supply Replacement

10.2.1.1. Required Tools

The only tool required is a medium-sized, flat-blade screwdriver.

10.2.1.2. Procedure

Power supply replacement requires disconnecting the AC Power. After having identified the faulty system component, replace it by following the procedure below:

1. Identify the power supply associated with the TCS to be replaced.
2. Turn OFF the corresponding Locking Subsystem Power Switch.

CAUTION

Turning OFF the wrong Power Switch will cause a general system failure.

3. Turn the captive thumb screws, at the top and bottom of the defective TCS module, counterclockwise until loose.
4. Grasp the Module Ejectors, next to the thumb screws at the top and bottom, and pull the TCS straight out from the board guides. Remove it from the cardfile.

5. Install the replacement TCS in the board guides and slide it in until the TCS engages the cardfile connector.
6. Turn the TCS thumb screws clockwise until they are finger-tight and the TCS is firmly positioned against the cardfile frame.
7. Turn ON the associated Power Switch.

NOTE

When a TCS is replaced, the calibration procedure should be rerun to verify the settings and update the threshold calculations.

10.2.2. Coupling Unit Replacement

The PCB is mounted in an aluminum box, which is installed within 15 feet (4.572 m) of the rail.

The coupling circuit is a single, 9" x 13" x 3/32" (22.86 cm x 32.02 cm x .238 cm.) circuit board. This circuit board has two identical circuits and two terminal strips for external connection of inputs and outputs. This single circuit board is used for two track circuits, the local transmit circuit, and the receiver circuit for an adjacent track circuit.

This unit could be replaced due to either:

- Circuit failure
- Aluminum box leaking (not water tight)

A medium-sized, flat-blade screwdriver is required to remove the circuit board.

The power to the two AF-902/904 track circuits connected to the Coupling Unit must be turned off prior to replacing the circuit board.

10.2.3. Bond Replacement

The bond track circuit consists of a few meters of 350 or 500 MCM heavy conductive cable, typically arranged in an "S" shape between the rails and connected at end points to the rails.

The cables from the coupling units are single loop wires that induce signals into the Loop and into the rails.

Once these cables are installed and verified as operational, there is very little, if anything, that may require replacement. If any damage occurs to this hardware, refer to the site's equipment and cable plans and the manufacturer's equipment manual.

10.3. Verification of System Repair

To ensure that the repairs have been performed correctly and that all replacement modules are fully functional, system verification testing must be performed. This verification procedure uses the AF-902/904 track circuit system test.

This specific test is described in Section 8.3.4 and consists of two procedures, tuning and calibration.

The AF-902/904 tuning procedure performs the following functions:

- Entry of carrier frequency
- Tuning of both coupling units

The AF-902/904 calibration procedure carries out the following system functions:

- Entry of Carrier Frequency, Track ID, and MLOK Address
- Setting of the Transmitter Tap and Vout to set rail current (Irail)
- Setting of the Receiver Tap and Shunt/Data Threshold
- Verification of 0.25 ohm shunt sensitivity

NOTE

Depending on the repair or replacement that is performed, the tuning procedure may not be required. Tuning is required as a setup procedure and when a coupling unit is replaced or if the track circuit frequency is changed.

Replacement of AF-902/904 track circuit PCBs do not warrant the tuning procedure. The calibration procedure should, however, be performed to verify the repairs.

11. TEKTRONIX SETUP PROCEDURE

This procedure uses the Tektronix TDS 3012B Oscilloscope and Tektronix A621 AC Current Probe to measure AF-902/904 peak currents. It assumes that the user is familiar with the basic operation of the Tektronix TDS 3012B. The procedure also assumes that the basic user settings (language, time, etc.) of the instrument have been configured. It is provided as an aid to setting up the Tektronix equipment prior to the actual tuning of the AF-902/904 system.

The following paragraphs are intended to help the user become familiar with the control layout of the Tektronix TDS 3012B Oscilloscope.

Observe that there are buttons along the bottom and right edge of the display. The function of these buttons will change, depending on other menu button selections. The current functions will be shown on the display.

There is a set of buttons along the top right side of the instrument. Only the Cursor, Select, and Coarse buttons and the adjustment knob between to the Coarse and Cursor buttons will be used in this procedure.

The remaining controls are grouped in four columns: Vertical, Horizontal, Trigger, and Acquire. This procedure will call out a control by Group – Control (button or knob). As an example, if adjustment of the position knob in the Horizontal group is required, the procedure will identify the control as Horizontal – Position.

The following table lists the steps in the setup procedure.

Table 11-1. Tektronix Setup Procedure

Step Number	Control	Setting	Observe
1	Power Switch	On	Display shows instrument settings box, followed by graduated screen.
2	Current Probe Range Switch	Connect to CH1 and clamp around AF-902/904 transmitted signal line. Set the Current Probe Range Switch to 10.	
3	AF-902/904	Using instructions in this manual, Table 6-9. Set up the AF-902/904 system to transmit a constant center frequency.	
4	Acquire – Autoset	Press button.	Display will show several cycles of the transmitted signal in yellow.
5	Acquire – Menu	Press button.	Display shows menu of options.
6	Horizontal – Scale	Adjust knob until the Sample Rate, lower right corner of display, is 500 KS/s.	
7	Vertical - CH1 (yellow) then Vertical - ~off	Press sequence to turn off analog signal display.	Yellow trace turns off.
8	Vertical – Math (red)	Press button.	Red trace shows on display, if not already on.
9	Right side of display top button	Select FFT source as CH1.	Displays CH1.
10	Right side of display 2nd button	Select FFT vertical scale to Linear RMS.	Displays Linear RMS.
11	Right side of display 3rd button	Select FFT window to Rectangular.	Displays Rectangular.
12	Bottom of Display – 2nd button	Make sure FFT is selected.	FFT.
13	Cursor Button	Press button.	Right side of display shows Cursor options.
14	Right Side of Display 3rd button	Select V Bars.	Red vertical line may appear on display.
15	Coarse Button	Press button.	Coarse Light turns on.
16	Coarse Adjust Knob	Turn knob until cursor position is greater than 100 kHz. (This is the @ parameter on the display).	Cursor moves off screen. This is a rough adjustment to move one of the cursors off of the screen.
17	Select Button	Press button.	Red vertical line will change from dashed to solid if on display.
18	Coarse Adjust Knob	Turn knob until cursor position is close to the center frequency that the AF-902/904 system is transmitting.	Cursor may be in display area. This is a rough adjustment and will be fine-tuned in the next step.
19	Coarse Button	Press to deselect Coarse adjust and fine tune cursor position to center frequency.	Cursor may be on display.
20	If the red data signal covers the display and makes it difficult to perform steps 16 – 19 using the Vertical – Scale knob	Reduce the amplitude of the displayed signal.	Information in right corner of display is visible.* Observe the small red line displayed at the top of the main display. It contains two small vertical red lines, a red triangle, and two blue brackets. This display is used to rough adjust the Main Display

Step Number	Control	Setting	Observe
21	Horizontal – Position Knob	Adjust until red triangle is over left-most red vertical line.	Red vertical cursor is near center of main display.
22	Horizontal – Scale	Adjust until blue brackets just enclose the red triangle.	Scale on main display will expand.
23	Horizontal – Position	Re-adjust until red cursor line is centered on the Main Display.	Center frequency signal is centered.
24	Vertical – Position	Adjust until baseline of waveform is approximately one unit from the bottom of the Main Display.	Waveform is moved to bottom of display.
25	Vertical – Scale	Turn until center frequency signal is approximately 4 to 6 units high.	Center frequency amplitude changes.
26	Horizontal – Scale	Turn until center frequency peak is approximately 1 display scale unit (1 cm) wide at the base.	Peak of waveform is easy to recognize.
27	Cursor Knob	Adjust until cursor line is at the center of the waveform. A small horizontal line on the cursor will be at the peak of the waveform.	The amplitude of the peak signal can now be read in the display. It is the value shown after the @ symbol. Scaling: @ x.yz mV = xy.z milliamps or @ xy.z mV = xyz milliamps Multiply mV by 10 to convert reading to milliamps.

12. PARTS LIST

12.1. Track Circuit Cardfile Overview

The cardfiles supplied for the AF-902 and AF-904 track circuits are listed in Table 12-1. Table 12-2 lists the part numbers for each variation of cardfile, and indicates which cardfile motherboard has direction relays. The location of these relays is shown in Figure 12-1 and Figure 12-2.

Table 12-1. AF-902/904 Track Circuit Cardfiles

PCB	Part Number
TCS	N12361001
Power Supply	N12360501

Table 12-2. AF-902/904 Track Circuit Cardfiles

Item	System Type	Power Input	Direction Relays	Part Number
1	AF-902	115 Vac	Yes	N12200202
2	AF-904	115 Vac	Yes	N12200204
3	AF-904	115 Vac	No	N12200210

12.2. Track Circuit Cardfile

Table 12-3 is the parts list for the AF-902/904 track circuit cardfile. The figures associated with this table are Figure 12-1 and Figure 12-2.

Table 12-3. Track Circuit Cardfile Parts List

Item Number	Description	Part Number	Used On 1 = N12200202 2 = N12200204 3 = N12200210
Not Shown	Single-Width Blockoff Plate	N4518502902	All
5	Frame, Support	R4518508101	All
10	Label, PCB Location	M12200901	All
15	Back Cover	N12200302	All
20	Handle 3/8″ SS	J0770460002	All
25	Screw 8-32 x 7/16″ Fil Hd SS	J5253010107	All
30	Washer, 10 Plate SS	J4751200110	All
35	Angle, Right Hand Support	M21050701	All
40	Angle, Left Hand Support	M21050702	All
45	Insulator	M4518112405	All
50	Insulator	M4518112406	All
60	PCB, AF-902 Two Track Motherboard	N12300101	1
	PCB, AF-904 Four Track Motherboard	N12300701	2
	PCB, AF-904 Motherboard W/O Relays	N12300702	3
65	Guide, PC 8″ E-800	J712112	All
75	Rivet, Pop, 1/8″ Dia., .313, SS	J4900370049	All
80	Washer, SS Lock No. 10	J4751210109	All

Item Number	Description	Part Number	Used On 1 = N12200202 2 = N12200204 3 = N12200210
85	Screw, SS 10-32 x 3/8″ Pan	J5072960106	All
90	Transformer, 115/230 V 25 VA	J7314000109	All
95	Washer, SS Plate No. 6	J4751200108	All
100	Insulator, Back Cover	M12201301	All
105	Nut, 6-32 SS Elastic	J048102	All
110	Label, AF-902	M12200601	1
	Label, AF-904	M12200701	2, 3
115	Jumper Cable	N4518945301	All
125	Cable Tie, Self-Locking	J703310	All
130	Bracket, Gusset	M4518509801	All
135	Power Line Filter, RFI	J7003840032	All
140	Terminal, Insul. Faston 250	J7091460480	All
145	Housing Assembly #640250-8	J7138040014	All
150	Nut, 4-40 Self-Locking	J0481620003	All
155	Sealant, Loctite 271	J041794	All
160	Wire, #18 AWG ETFE White	A0458480084	All
170	Contact, High Force 640706-1	J7091461130	All
175	Panel, Rear Access	N12201402	All
180	Terminal, Faston, FL87 x 020″, 22-18 AWG, 300 V	J7313990018	All
185	Washer, Silicone Bronze Nickel Plated	J047701	All
190	Nut, #8-32 Hex	J048198	All
195	Terminal, AMP 320554	J731223	All
220	Label	M12200304	All
225	Label	M12201403	All
230	Cover	M12201801	All
235	Washer, #5 Plated Flat Steel	J475175	All
240	Label, PESG-C-1	J0759550047	All
245	Terminal, Faston, FL87 x 020″, 16-14 AWG, 300 V	J7091460555	All
250	Label, 1.00" x 0.38″, White	J075962	All
255	Tag, Sleeve, 1/8″ x .75″, White	J7928223006	All
260	Insulation Barrier	M12202001	All
265	Peg, Keying for Strip	J7091460473	All
270	Rivet, Pop, 1/8″ Dia., 0.251, SS	J4900370048	All
275	Cable Tie, Mounting Base, Two-Way, Nylon	J792669	All
285	Screw, 4-40 x 7/16″ Pan Hd SS	J5001240116	All
290	Screw, 4-40 x 7/8″ Pan SS	J5072970114	1
295	Screw, SS 8-32 x 7/1″6 Pan	J5072950107	1
300	Washer, SS Lock No. 8	J4751210108	1
305	Washer, SS Plate No. 8	J4751200109	1
310	Screw, Thumb, 8-32 x 7/16″ SS	J5072770014	1
315	Compound, RTV Adhesive/Seal	J041943	All
320	Gasket, Foam	M12202101	All
325	Washer, SS #6 Shake-Proof	J4751210126	1
330	Terminal, Female Right Angle	J7313990071	All
335	CE Label, Matte Silver	J0759550051	1
340	PCB, Output Filter	N17400301	1
345	Cover, Lexan	M12202201	1
350	Standoff, 3/8″ Hex 8-32	J7927750007	1
355	Grommet, Strip Nylon 1/8″	A751316	1

Item Number	Description	Part Number	Used On 1 = N12200202 2 = N12200204 3 = N12200210
998	Label, Transfer, 5″ Roll 7209935	A0775010003	All
999	Ribbon, Thermal Transfer	A0775010007	All

12.3. Cardfile Motherboard Direction Relays

The motherboard (N12300101 and N12300201) in the AF-902/904 cardfiles support the direction relays listed in Table 12-4. Motherboard N12300101 in the AF-902 (two track circuit) cardfile has two different types of relays. Motherboard N12300201 in the AF-904 (four track circuit) cardfile has four relays: two 12 volt relays (J7261530413) and two socket relays (J5817820017). Figure 12-1 and Figure 12-2 show the location of these relays on the respective motherboard. Figure 2-7 shows the location of the direction relays on the AF-902 motherboard. Note that the relays appear as dashed boxes between the PCB connectors in the second row. Note that four track circuit motherboard N12300702 has no relays.

Table 12-4. Motherboard Direction Relays Parts List

Item Number	Description	Part Number
1	Relay, 12 V, H-462, 1323, 420/89 (RLY1N RLY1R RLY2N RLY2R)	J7261530413

12.4. AF-902 and AF-904 Cardfile PCBs

The AF-902 and AF-904 cardfiles contain the PCBs listed in Table 12-5. The figures associated with this table are Figure 1-3, and Figure 1-4.

Table 12-5. Cardfile PCBs Parts List

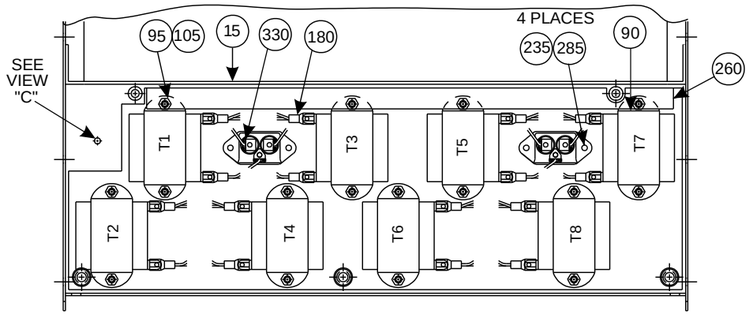
Description	Part Number
Track Circuit Controller System (TCS)	N12361001
Power Supply	N12360501

12.5. Coupling Units

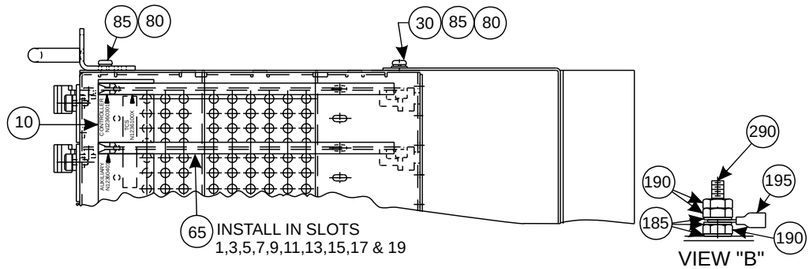
The coupling units associated with the AF-902 and AF-904 track circuits are listed in Table 12-6.

Table 12-6. Coupling Units Parts List

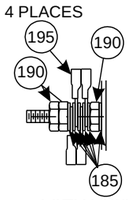
Item Number	Description	Part Number
1	Coupling Unit for inductively-coupled locations ("S", "O", or "I" bonds) (See Figure 1-7 through Figure 1-9.)	N37500601
2	Coupling Unit for "direct injection" locations (e.g., crossovers) (See Figure 1-10.)	N37500603
3	Coupling Unit for "cab signaling loop" locations (See Figure 2-4.)	N37500604



VIEW "A"
SHOWING INSIDE OF BACK COVER (IT.15)



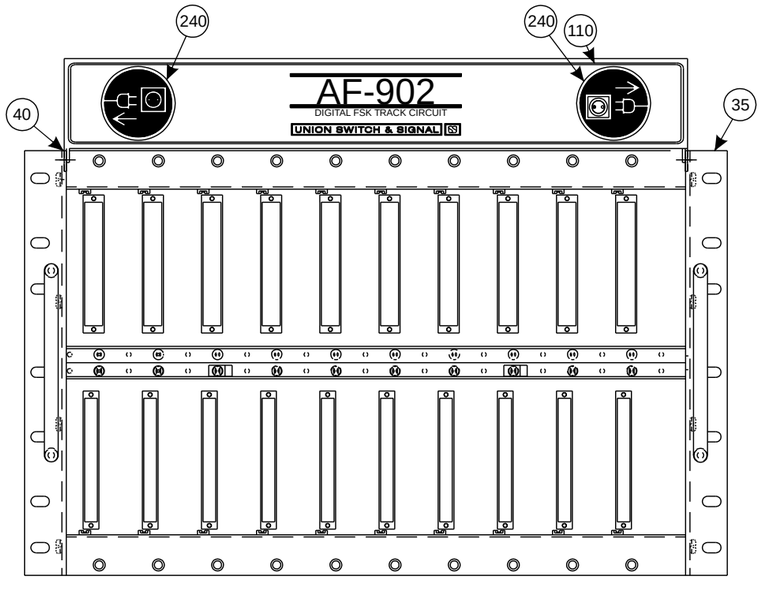
VIEW "B"
SHOWING STACKING OF HARDWARE ON GROUND STUD FOR REF. ONLY

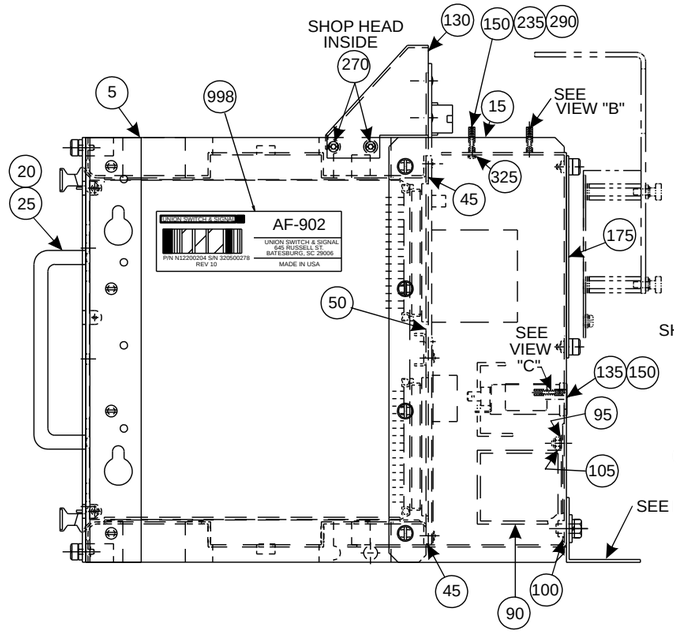


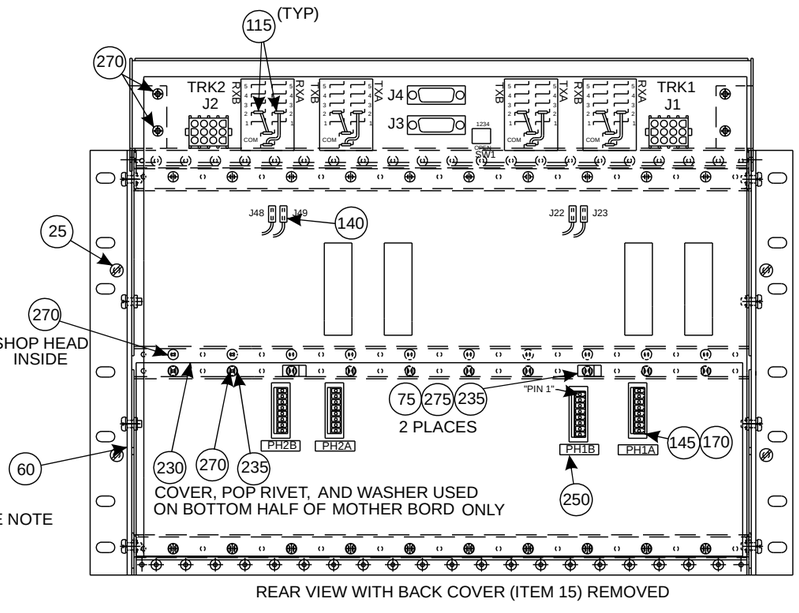
VIEW "C"
SHOWING STACKING OF HARDWARE ON GROUND STUD

MOTHERBOARD KEYING SCHEDULE		
BAR	INSTALL KEYING PEGS (ITEM 265) INTO POSITION	BOARD REF.
KEY 1B	1, 2, 5, 6, 8, 9	N123 60301 OR N1236100X
KEY 2B	1, 2, 5, 6, 8, 10	N 12360401
KEY 3B	1, 2, 5, 6, 8, 11	N 12360501
KEY 4B	1, 2, 5, 6, 8, 9	N123 60301 OR N1236100X
KEY 5B	1, 2, 5, 6, 8, 10	N 12360401
KEY 6B	1, 2, 5, 6, 8, 9	N123 60301 OR N1236100X
KEY 7B	1, 2, 5, 6, 8, 10	N 12360401
KEY 8B	1, 2, 5, 6, 8, 11	N 12360501
KEY 9B	1, 2, 5, 6, 8, 9	N123 60301 OR N1236100X
KEY 10B	1, 2, 5, 6, 8, 10	N 12360401

NOTE:
FOR SHELF MOUNTED INSTALLATIONS, USE BRACKET PART NUMBER M12201601 AND MOUNTING HARDWARE J4751200112, J5000970108 AND J4751210111.
THE BRACKET AND HARDWARE MUST BE ORDERED SEPARATELY.

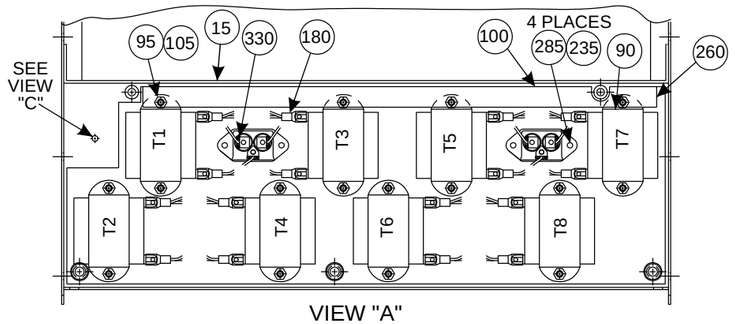




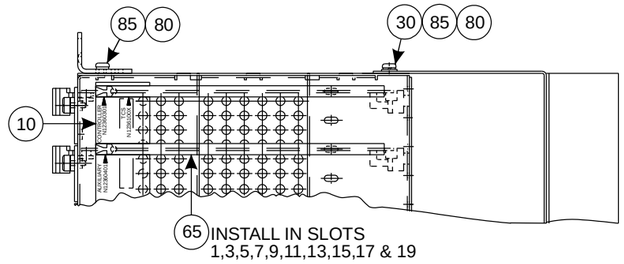


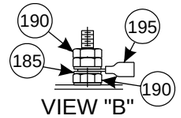
REAR VIEW WITH BACK COVER (ITEM 15) REMOVED

Figure 12-1. AF-902 Track Circuit Cardfile

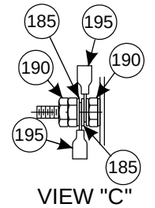


VIEW "A"
SHOWING INSIDE OF BACK COVER (ITEM 15)





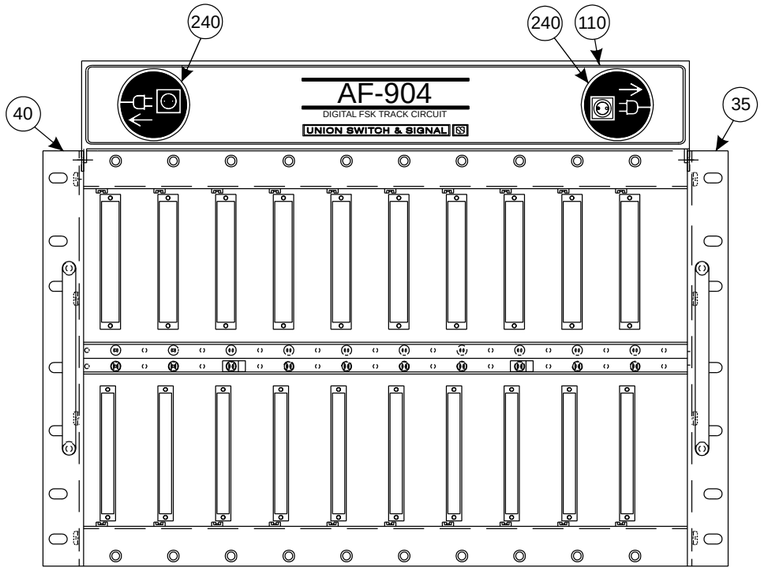
VIEW "B"
SHOWING STACKING OF HARDWARE ON GROUND STUD

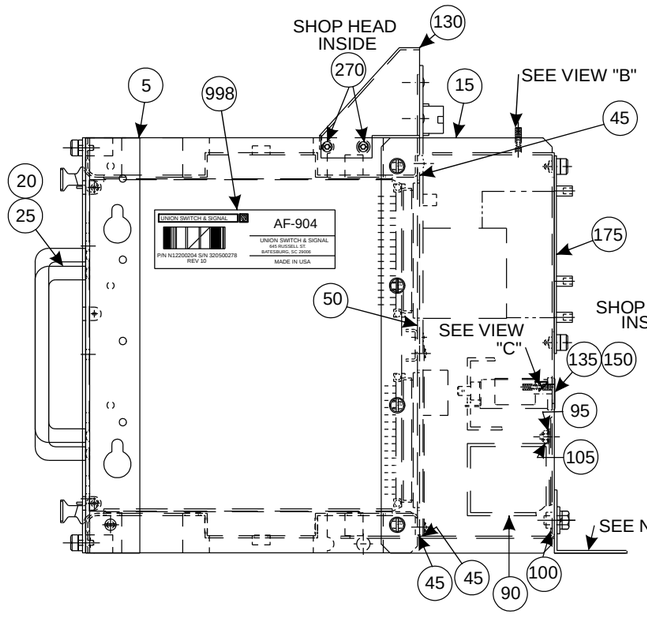


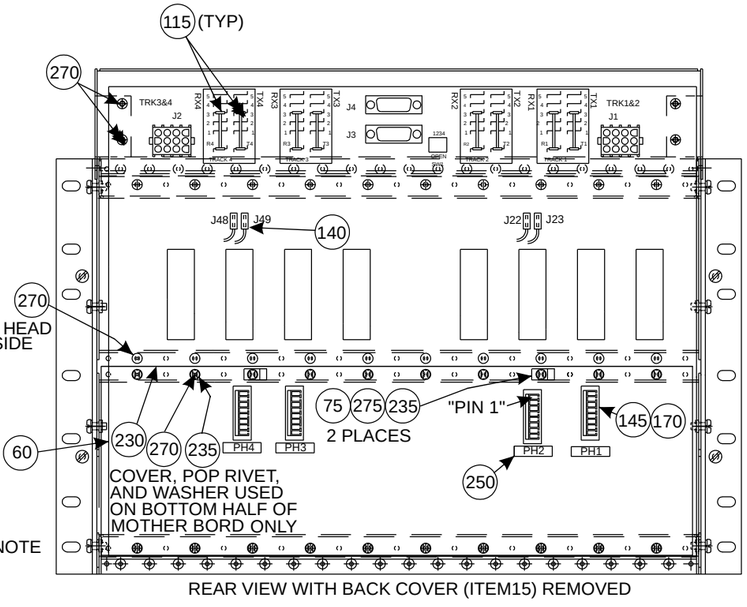
VIEW "C"
SHOWING STACKING OF HARDWARE ON GROUND STUD

NOTE:

FOR SHELF MOUNTED INSTALLATIONS, USE BRACKET PART NUMBER M12201601 AND MOUNTING HARDWARE J4751200112, J5000970108 AND J4751210111. THE BRACKET AND HARDWARE MUST BE ORDERED SEPARATELY.







REAR VIEW WITH BACK COVER (ITEM15) REMOVED

102.018T.00

Figure 12-2. AF-904 Track Circuit Cardfile

13. RAIL TEAM AND TECHNICAL SUPPORT

The Rapid Action Information Link Team (RAIL Team) is a group of experienced product and application engineers ready to assist you to resolve any technical issues concerning this product. Contact the RAIL Team in the United States at 1-800-652-7276 or by e-mail at railteam@ansaldo-sts.us.

APPENDIX A CHARTS and TABLES

Table A-1. Next Frequency Chart

FREQUENCY (kHz)	BINARY VALUE		
9.5	0	0	0
10.5	0	0	1
11.5	0	1	0
12.5	0	1	1
13.5	1	0	0
14.5	1	0	1
15.5	1	1	0
16.5	1	1	1

Table A-2. Speed Chart *(representative speeds)*

Speed (kph)	Binary Value			
0	0	0	0	0
3	0	0	0	1
5	0	0	1	0
10	0	0	1	1
15	0	1	0	0
30	0	1	0	1
35	0	1	1	0
40	0	1	1	1
45	1	0	0	0
50	1	0	0	1
55	1	0	1	0
60	1	0	1	1
65	1	1	0	0
70	1	1	0	1
75	1	1	1	0
80	1	1	1	1

Table A-3. Distance Chart

(representative distance)

DISTANCE (METERS)	BINARY VALUE						
0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	1
12	0	0	0	0	0	1	0
18	0	0	0	0	0	1	1
24	0	0	0	0	1	0	0
30	0	0	0	0	1	0	1
36	0	0	0	0	1	1	0
42	0	0	0	0	1	1	1
48	0	0	0	1	0	0	0
54	0	0	0	1	0	0	1
60	0	0	0	1	0	1	0
66	0	0	0	1	0	1	1
72	0	0	0	1	1	0	0
78	0	0	0	1	1	0	1
84	0	0	0	1	1	1	0
90	0	0	0	1	1	1	1
96	0	0	1	0	0	0	0
102	0	0	1	0	0	0	1
108	0	0	1	0	0	1	0
114	0	0	1	0	0	1	1
120	0	0	1	0	1	0	0
126	0	0	1	0	1	0	1
132	0	0	1	0	1	1	0
138	0	0	1	0	1	1	1
144	0	0	1	1	0	0	0
150	0	0	1	1	0	0	1
156	0	0	1	1	0	1	0
162	0	0	1	1	0	1	1
168	0	0	1	1	1	0	0
174	0	0	1	1	1	0	1
180	0	0	1	1	1	1	0
186	0	0	1	1	1	1	1
192	0	1	0	0	0	0	0
198	0	1	0	0	0	0	1
204	0	1	0	0	0	1	0
210	0	1	0	0	0	1	1
216	0	1	0	0	1	0	0
222	0	1	0	0	1	0	1
228	0	1	0	0	1	1	0
234	0	1	0	0	1	1	1
240	0	1	0	1	0	0	0
246	0	1	0	1	0	0	1
252	0	1	0	1	0	1	0
258	0	1	0	1	0	1	1
264	0	1	0	1	1	0	0
272	0	1	0	1	1	0	1
278	0	1	0	1	1	1	0
284	0	1	0	1	1	1	1
290	0	1	1	0	0	0	0
296	0	1	1	0	0	0	1
302	0	1	1	0	0	1	0
308	0	1	1	0	0	1	1
314	0	1	1	0	1	0	0
320	0	1	1	0	1	0	1
326	0	1	1	0	1	1	0
332	0	1	1	0	1	1	1
338	0	1	1	1	0	0	0
344	0	1	1	1	0	0	1
350	0	1	1	1	0	1	0
356	0	1	1	1	0	1	1
362	0	1	1	1	1	0	0
368	0	1	1	1	1	0	1
372	0	1	1	1	1	1	0
378	0	1	1	1	1	1	1

DISTANCE (METERS)	BINARY VALUE						
384	1	0	0	0	0	0	0
390	1	0	0	0	0	0	1
396	1	0	0	0	0	1	0
402	1	0	0	0	0	1	1
408	1	0	0	0	1	0	0
414	1	0	0	0	1	0	1
420	1	0	0	0	1	1	0
426	1	0	0	0	1	1	1
432	1	0	0	1	0	0	0
438	1	0	0	1	0	0	1
444	1	0	0	1	0	1	0
450	1	0	0	1	0	1	1
456	1	0	0	1	1	0	0
462	1	0	0	1	1	0	1
468	1	0	0	1	1	1	0
472	1	0	0	1	1	1	1
474	1	0	1	0	0	0	0
478	1	0	1	0	0	0	1
480	1	0	1	0	0	1	0
484	1	0	1	0	0	1	1
486	1	0	1	0	1	0	0
490	1	0	1	0	1	0	1
496	1	0	1	0	1	1	0
500	1	0	1	0	1	1	1
506	1	0	1	1	0	0	0
512	1	0	1	1	0	0	1
518	1	0	1	1	0	1	0
524	1	0	1	1	0	1	1
530	1	0	1	1	1	0	0
536	1	0	1	1	1	0	1
540	1	0	1	1	1	1	0
546	1	0	1	1	1	1	1
552	1	1	0	0	0	0	0

DISTANCE (METERS)	BINARY VALUE						
558	1	1	0	0	0	0	1
564	1	1	0	0	0	1	0
570	1	1	0	0	0	1	1
600	1	1	0	0	1	0	0
630	1	1	0	0	1	0	1
660	1	1	0	0	1	1	0
690	1	1	0	0	1	1	1
720	1	1	0	1	0	0	0
750	1	1	0	1	0	0	1
780	1	1	0	1	0	1	0
810	1	1	0	1	0	1	1
840	1	1	0	1	1	0	0
870	1	1	0	1	1	0	1
900	1	1	0	1	1	1	0
930	1	1	0	1	1	1	1
960	1	1	1	0	0	0	0
990	1	1	1	0	0	0	1
1020	1	1	1	0	0	1	0
1050	1	1	1	0	0	1	1
1080	1	1	1	0	1	0	0
1110	1	1	1	0	1	0	1
1140	1	1	1	0	1	1	0
1170	1	1	1	0	1	1	1
1200	1	1	1	1	0	0	0
1350	1	1	1	1	0	0	1
1500	1	1	1	1	0	1	0
1650	1	1	1	1	0	1	1
1800	1	1	1	1	1	0	0
1950	1	1	1	1	1	0	1
2400	1	1	1	1	1	1	0
2900	1	1	1	1	1	1	1

End of Manual